Abstract

Cropping allocations have normally been studied using frameworks that assume the existence of a representative farmer who cares about maximising gross margin. Evidence has shown that results obtained from these studies to predict cropping allocations in response to policy reforms are not satisfactory. On the other hand, an alternative research using multivariate models (i.e. models that consider economic and social-psychological variables to explain farmers’ behaviour) has been developed with the purpose of identifying farmers’ motivations to adopt specific environmental policies. However, this research has not been extended to study strategic cropping decisions. This is surprising given the fact that policy reforms strongly affect the allocation of crops when they are accompanied with the elimination of domestic distorting policies. The objective of this thesis is to fill this gap by proposing a novel holistic multivariate model designed exclusively to study farmers’ strategic cropping decisions. The proposed model integrates a number of alternative and complementary approaches that can explain farmers’ strategic behaviour. The model was applied to a sample of ex-sugar beet farmers in the West Midlands region of the UK to investigate the way in which these individuals adjusted to the Sugar Regime reform introduced on 20th February 2006. As a consequence of this reform, the sugar beet factory located in Allscott in Shropshire was closed and the sugar beet growers in this area adjusted by replacing sugar beet with alternative crops. Evidence has revealed that these farmers replaced sugar beet with crops with low gross margin such as oilseed. This choice is puzzling because other crops with high levels of gross margin such as carrots and parsnips were also available when the reform was implemented. The proposed multivariate model not only was useful to explain this choice, but also identified heterogeneous behavioural responses that no related research has identified so far.
# TABLE OF CONTENTS

Abstract .................................................................................................................. i

TABLE OF CONTENTS ........................................................................................... ii

Dedicatory ................................................................................................................. xi

Acknowledgments .................................................................................................. xii

Glossary of Terms, Abbreviations and Acronyms .............................................. xiii

Chapter One

FARMERS CROPPING STRATEGIES IN RESPONSE TO THE SUGAR REGIME REFORM: STATING THE PROBLEM

1.1 Introduction ....................................................................................................... 1

1.2 Research Approach ............................................................................................ 5

  1.2.1 The Pilot Investigation .................................................................................. 6

  1.2.2 The Static Stage of the Research ................................................................ 7

  1.2.3 The Dynamic Stage of the Research ............................................................ 7

1.3 Thesis Structure ................................................................................................. 9

1.4 Chapter Summary ............................................................................................. 12

Chapter Two

THE CONTEXT OF THE STUDY: ESTABLISHING THE PROBLEM

2.1 Introduction ....................................................................................................... 15

2.2 The Sugar Sector in the UK ............................................................................. 16

2.3 The Sugar Regime Reform (SRR) ................................................................... 20

2.4 The Effect of the Sugar Regime Reform on the West Midlands Region ........ 23
2.5 Strategies adopted by the Sugar Beet Growers to adjust to the SRR ………. 27
2.6 Research Questions ................................................................. 31
2.7 Chapter Summary ..................................................................... 32

Chapter Three
ALTERNATIVE APPROACHES EXPLAINING FARMERS’ CROPPING DECISIONS

3.1 Introduction ............................................................................. 34
3.2 Dynamic Capabilities Approach ............................................... 37
  3.2.1 Historical Background to Strategic Management: contextualising Dynamic Capabilities ........................................... 38
  3.2.2 Dynamic Capabilities ............................................................ 43
  3.2.3 Dynamic Capabilities and the ESBF ...................................... 47
  3.2.4 Examples of Strategies adopted by Firms in Response to Exogenous Shocks ............................................................. 50
3.3 The utilitarian approach ............................................................. 57
  3.3.1 The Gross Margin Paradigm .................................................. 58
  3.3.2 The utilitarian approach ....................................................... 60
  3.3.3 The utilitarian approach and the ESBF from the EV point of view .. 79
3.4 The Multiple Goals Approach .................................................... 80
  3.4.1 The multiple Goals Approach and Extensions ......................... 81
  3.4.2 The multiple Goals Approach and the ESBF ......................... 83
3.5 The Theory of Planned Behaviour .............................................. 84
  3.5.1 Rationale underlying the Theory of Planned Behaviour ............. 84
  3.5.2 The Theory of Planned Behaviour and the ESBF .................... 88
3.6 Market and Material Resources Barriers Approach ....................... 89
Chapter Four

THEORETICAL DEVELOPMENT: THE PROPOSED HOLISTIC MULTIVARIATE MODEL

4.1 Introduction ............................................................................................................ 102

4.2 The Representative Farmer and the Benchmark Condition ............................... 107
   4.2.1 Establishing the Benchmark Condition ...................................................... 107
   4.2.2 Implications of the Existence of a Representative Farmer ....................... 109

4.3 Behavioural Patterns across Farmers: Introducing Asymmetries into the
   Benchmark Condition ......................................................................................... 110
   4.3.1 Introducing Heterogeneous Market and Material Resources
       Barriers: the Multiple Efficient Frontiers Theory ........................................ 111
   4.3.2 Introducing the Multiple Goals Approach and the Theory of
       Planned Behaviour ......................................................................................... 128
   4.3.3 Introducing Dynamic Capabilities ............................................................ 136

4.4 Farmers’ classification according to their strategic behaviour ....................... 147
   4.4.1 Exiting Typologies for classifying Individuals according to their
       Strategic Behaviour ....................................................................................... 148
   4.4.2 The Income-Risk Matrix .......................................................................... 151

4.5 Chapter Summary .............................................................................................. 154

Chapter Five

RESEARCH METHODOLOGY
5.1 Research Philosophy and Research Approach ................................................. 161

5.1.1 Research Philosophy ................................................................. 163

5.1.2 Research Approach ................................................................. 166

5.1.3 Research Strategy ................................................................. 166

5.1.4 Method Choices ................................................................. 168

5.1.5 Time Horizons ................................................................. 168

5.1.6 Techniques and Procedures .................................................. 169

5.1.7 Schematic Representation of the Research Process ............... 170

5.2 Common Methods Variance and Common Methods Biases .......... 172

5.3 Methods used in the Research .................................................. 179

5.3.1 Method used in the pilot investigation ................................. 179

5.3.2 Method used in the Questionnaire Design ......................... 179

5.3.3 Sampling method ................................................................. 181

5.3.4 Methods adopted in the Static Stage of the Research ............. 189

5.3.5 Methods adopted in the Dynamic Stage of the Research and
Farmers’ Classification ................................................................. 212

5.3.6 Additional Econometric Tests ............................................... 218

5.4 Chapter Summary ................................................................. 219

Chapter Six

FINDINGS AND RESULTS IN THE STATIC STAGE OF THE RESEARCH

6.1 Findings from the Pilot Investigation ........................................... 221

6.1.1 First Stage of the Pilot Investigation .................................... 222

6.1.2 Second Stage of the Pilot Investigation ................................ 223

6.2 Phase I of the Static Stage of the Research: General Characteristics of the
ESBF ................................................................. 233
6.2.1 Characteristics of the ESBF in the sample ........................................ 234
6.2.2 Crops chosen by the ESBF ................................................................. 237

6.3 Phase II of the Static Stage of the Research: Dynamic Capabilities ........ 241

6.3.1 Analysis of the Determinants of DC for the ESBF in the Sample
..................................................................................................................... 242

6.3.2 Concluding the Analysis of DC ........................................................... 255

6.4 Phase III of the Research: Strategic Behaviour in Stable Business

Environments .............................................................................................. 257

6.4.1 Testing the HRA and the HSCRA using an experimental method
..................................................................................................................... 259

6.4.2 Testing the HOP by estimating the EPL .............................................. 265

6.4.3 Testing the HNE, HIC and HSI ............................................................ 272

6.4.4 The Outliers ...................................................................................... 286

6.5 Conclusions .......................................................................................... 290

Chapter Seven

FINDINGS AND RESULTS IN THE DYNAMIC STAGE OF THE RESEARCH

7.1 Introduction .............................................................................................. 295

7.2 Results of the Dynamic Stage of the Research: testing the HAD and the HAE
..................................................................................................................... 297

7.2.1 Strategic Behaviour in Response to the Exogenous Shock ................. 297

7.2.2. Farmers’ Classification According to their Behavioural Response
..................................................................................................................... 308

7.2.3 Non-economic Drivers Explaining Differences among Classes of Farmers ........................................................................................................... 327

7.2.4 Non-economic Drivers Explaining Differences among Subclasses of
Farmers .................................................. 252

7.3 Managerial and Policy Implications of the Results ....................... 360

7.3.1 Managerial Implications of the Results .............................. 360

7.3.2 Policy Implications of the Results .................................. 364

7.3.3 A Model to Predict Farmers’ Behaviour in Response to the Removal
of Material Resource Restrictions ........................................ 366

7.4 Conclusions ......................................................... 370

Chapter Eight

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

8.1 Introduction .......................................................... 374

8.2 Research Development to Achieve the main Objective of the Research ...... 376

8.2.1 Approaches Used in the Proposed Multivariate Model ............... 377

8.2.2. Contributions Associated with the Proposed Multivariate Model .. 378

8.3 The Static Stage of the Research ..................................... 378

8.3.1 Results of Phase I of the Static Stage of the Research ............... 381

8.3.2 Results of Phase II of the Static Stage of the Research ............... 382

8.3.3 Results of Phase III of the Static Stage of the Research ............... 385

8.3.4 Research Questions ............................................... 390

8.3.5 Contributions of the Static Stage of the Research .................. 391

8.4 The Dynamic Stage of the Research .................................. 392

8.4.1 Research Findings of the Dynamic Stage of the Research .......... 393

8.4.2 Contributions of the Dynamic Stage of the Research ............... 396

8.5 Implications and Recommendations from the Research .................. 397

8.6 Weakness and Strengths of the Investigations, and Recommendations for
Appendix J: Calculations Developed in the Simulation Presented in Figure 4.5
..................................................................................................................474

Appendix K: Calculations Developed in the Simulation Presented in Figure 4.14
..................................................................................................................477

Appendix L: Farmers Questionnaire ......................................................... 481

Appendix M: Letter sent to the British Sugar Corporation ......................... 488

Appendix N: Letter sent to the farmers of the West Midlands by means of the NFU newsletter .................................................................................................................. 489

Appendix O: Detailed Explanation of How the Variance of the Portfolio of Crops is Calculated Based on a Practical Example ......................................................... 490

Appendix P: Proving that an Ordinal Utility can be Rescaled Without Affecting its Meaning in Terms of Individuals’ Preferences ......................................................... 494

Appendix Q: Prices, intermediaries and uses of the crops adopted by the ESBF in 2008 .................................................................................................................................................................................. 501

Appendix R: Extended Version of the Regression Model Presented in Table 6.7
.................................................................................................................................................................................. 503
Dedicatory

To my beloved Wife and Son

xi
Acknowledgments

I would like to thank the Business School of Wolverhampton University and all those who gave me advice and guidance throughout the period of time in which this thesis was being produced. I would like to thanks in particular my supervisors Professor Leslie Worrall and Dr Graham Tate for their constant support and friendship; Professor Michael Haynes, Dr Silke Machold and Dr Yong Wang for their valuable observations at different stages of the research; Mr Steve Greenfield for his important help and support in the data collection stage of the investigation; and Mrs Sarah Estibeiro for her support in the edition of this thesis.

I am thankful for the interest and support given by my wife, my son, my parents and my sisters.

Finally, I am grateful for the financial support provided by Oldecra Foundation.
Glossary of Terms, Abbreviations and Acronyms

**ABC-Absorptive capability** - the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends in order to innovate.

**AC-Adaptive capability** - a firm’s ability to identify and capitalize on emerging market opportunities.

**ASBF-Allscott sugar beet factory** - the processing sugar factory that used to operate at Allscott before the implementation of the reform of the Sugar Regime.

**BS-British Sugar Corporation** - the business that is formed of the factories located in the UK and that process sugar from sugar beet.

**CAP-Common Agricultural Policy** - set of policies adopted by the European Union to protect the agricultural sector.

**CARA-constant absolute risk aversion** - terms used to describe the condition in which the coefficient of absolute risk aversion does not depend on the level of wealth.

**DARA-decreasing absolute risk aversion** - terms used to describe the situation in which the degree of risk aversion decreases as income (wealth) increases.

**DC-Dynamic Capabilities** - capabilities that allow managers to modify their resources in response to environmental changes in order to obtain or maintain competitive advantages.

**DEFRA-Department of Environment, Food and Rural Affairs** - Governmental Department in England that deals with agricultural issues.

**DSR-Dynamic Strategic Research** - Research that studies how individuals make their strategic decisions in dynamic environments.

**EPL-Efficient Portfolio Line** - line that represents farmers’ optimal decisions on crop allocations in the gross margin-variance geometric space.

**ESBF-ex sugar beet farmers of the West Midlands** - farmers that used to produce sugar beet before the introduction of the reform of the Sugar Regime in 2006.

**EUF-exponential utility function** - mathematical function used to represent agents’ utility in risky business environments.

**EV-Mean-Variance Analysis** - considers the incentives of agents to form portfolios of assets in order to reduce the non-systematic risk.

**FAO-Food and Agricultural Organisation** - organization of the United Nations whose objective is to promote development in the agricultural sector.

**FBR-Farmers Behavioural Research** - Research that studies the economic and non-economic determinants of farmers’ strategic behaviour.
HAD-hypothesis of adaptation by departing from the EPL-hypothesis establishing that farmers, in order to adapt to a removal of market and resource barriers, depart from the EPL.

HAE-hypothesis of adaptation along the EPL-hypothesis establishing that farmers, in order to adapt to a removal of market and resource barriers, move along the EPL.

HIC- hypothesis of determinants of dynamic capabilities associated with individual characteristic-hypothesis establishing that among the determinants associated with individual characteristics, only differences of self-motivation and attitudes towards risk generate deviations around the EPL.

HIS-hypothesis of determinants of dynamic capabilities associated with Social Interaction-hypothesis establishing that when farmers face market and material resources barriers preventing them from producing more profitable crops, social interaction (i.e. participation in collaborative alliances and social networks) can only generate deviations around the EPL when it helps them either to gain negotiation power or productive efficiency.

HNE-hypothesis of non-economic drivers-hypothesis establishing that farmers’ cropping decisions are influenced by non-economic drivers.

HOP-hypothesis of optimum path-hypothesis establishing that if risk averse farmers have the same attitudes towards risk, then their crop allocations define an optimum path representing their optimum decisions under different efficient frontiers.

HRA-hypothesis of risk aversion-hypothesis establishing that the ESBF are risk averse.

HSCRA-hypothesis of similar coefficient of risk aversion-hypothesis establishing that farmers have the same attitude towards risk.

IC- Innovative capability—a firm’s ability to develop new products and/or markets, through aligning strategic innovative orientation with innovative behaviours and processes.

NF-neutral farmer—a farmer who chooses a portfolio of crops with the same levels of expected gross margin and business risk after an exogenous change is verified.

NFU-National Farm Union-national union of farmers in the UK.

PRE-progressive risk enlarger farmer—a farmer who chooses a portfolio of crops with larger levels of expected gross margin and business risk after an exogenous change is verified.

PRS-progressive risk saver farmer—a farmer who chooses a portfolio of crops with a larger expected gross margin and a smaller business risk after an exogenous change is verified.

QUF-quadratic utility function—mathematical function used to represent agents’ utility in risky business environments.
**RBV-resource based view** - a model arguing that competitive advantages can be sustained with heterogeneous resources that are valuable, rare, imperfectly imitable and imperfectly substitutable.

**RRE-regressive risk enlarger farmer** - a farmer who chooses a portfolio of crops with a smaller expected gross margin and a larger business risk after an exogenous change is verified.

**RRS-regressive risk saver farmer** - a farmer who chooses a portfolio of crops with smaller levels of expected gross margin and business risk after an exogenous change is verified.

**SD-Standard Deviation** - statistical measurement used to determine the degree of dispersion of the observations of a sample or population around the mean.

**SEU-Subjective Expected Utility hypothesis** - assumes that economic decisions under uncertainty are gambles in which each possible outcome is associated with a particular level of utility.

**SPS-Single Payment Scheme** - system of decoupled payments that were introduced in the 2003 CAP reform.

**SRR-sugar regime reform** - corresponds to the CAP reforms that was introduced and implemented in the sugar sector on 20th February 2006.

**SWOT** - acronym for strengths, weaknesses, opportunities and threats.

**TIV** - acronym for total index value.

**VRIN** - acronym for resources that are valuable, rare, imperfectly imitable and non-substitutable.
Chapter One: FARMERS’ CROPPING STRATEGIES IN RESPONSE TO THE SUGAR REGIME REFORM: STATING THE PROBLEM

1.1 Introduction

Since the 1990s important policy changes in agriculture have been implemented by different countries in order to improve rural competitiveness (Ridier and Jacquet, 2002). In the European Union, in particular, policy changes have been introduced as reforms of the Common Agricultural Policy (CAP) with the objective of eliminating distorting instruments of domestic policy such as production quotas and subsidised agricultural prices (Agra Europe, 2006). A key aspect of these reforms is the incorporation of environmental objectives and the introduction of non-distorting lump sum transfers used to compensate farmers for the elimination of distorting domestic policies (these transfers are referred to as Single Payments). Researchers in this area have developed holistic multivariate models (i.e. models that consider economic and social psychological variables) which aim to determine farmers’ responses to the introduction of these environmental objectives and Single Payments (see, for example, Rehman et al., 2007). Surprisingly, however, there has been a lack of research focusing on the strategic choices that farmers make in their crop allocations in response to policy reforms. This is surprising because one of the most important impacts of the elimination of distorting domestic supports is upon farmers’ ability to sustain their competitive position in the market. For example, it has been found that the level of business risk in the rural business environment increases after the implementation of policy reforms¹. This is because many crops are now exposed to the instability of prices that characterise

¹ Business risk is the aggregate effect of all the uncertainty influencing the levels of gross margin made by a firm. This comprises production risk arising from weather uncertainty, market uncertainty arising from the unpredictable nature of output prices, institutional risk arising from unpredictable changes of rules affecting production, and personal risk arising from unpredictable events such as illness (Hardaker et al., 1998).
international commodity markets (Sckokai and Moro 2006, White and Dawson 2005, and Hennessy 1998). As a consequence, farmers have to alter their crop allocations with the objective of internalising this additional level of business risk which is not always an easy task given the presence of market barriers (e.g. power imbalance in the relationship between retailers and producers) and, for example, land quality constraints which limit their cropping choices (Burt and Sparks, 2003; and Collins and Burt, 1999).

Cropping choices have traditionally been studied using models that have a tendency to oversimplify farmers’ strategic behaviour. For example, is it common to find frameworks that assume the existence of a representative farmer (although not all models adopt this assumption) whose behaviour is supposed to characterise that of all the farmers affected by policy reforms (see, for instance, Sckokai and Moro, 2006). However, there is no reason to assume that farmers facing different farming conditions such as different land qualities or market barriers will behave in the same way.

This oversimplification could, in practice, generate important biases in the results obtained from these frameworks. In fact, prediction biases are identified in this thesis in a work developed by the Rural Business Unit of the University of Cambridge and the Royal Agricultural College (2004). This work was developed to predict the crop allocations made by sugar-beet growers in response to the Sugar Regime reform introduced in 20th February 2006. For this purpose, the researchers used a framework assuming the existence of a representative farmer whose objective was to maximise gross margin. As discussed in detail in Chapter Two, the predictions made by this particular modelling approach were found to be significantly different from the actual cropping patterns subsequently observed in the West Midlands region of the UK. This
suggests that a more holistic approach that integrates not only economic considerations, but also social-psychological drivers is needed to study farmers’ cropping decisions.

The principal objective of this thesis is to fill this gap by proposing a novel multivariate model that integrates a number of different approaches into a single framework to study economic and non-economic drivers that influence farmers’ strategic cropping decisions. That is, the aim of this thesis is to produce a more effective modelling framework with high predictive validity.

The proposed multivariate model differs from related frameworks in a number of aspects. Firstly, as explained above, the multivariate models which explored how farmers adjust to policy reforms have generally been developed with the purpose of determining farmers’ responses to the introduction of environmental practices or the introduction of single payments. In contrast, the multivariate model proposed in this thesis was designed to study exclusively farmers’ cropping decisions and can be used to graphically identify behavioural patterns across farmers. This is in fact the main contribution of the present research. Secondly, related multivariate model only integrate two approaches in order to study farmers’ behaviour: the multiple goals approach; and the theory of planned behaviour (a detailed description of these approaches is presented in Chapter Three). In contrast, the proposed multivariate model not only uses these approaches, but also innovatively incorporates other approaches that can also be used to explain farmers’ strategic behaviour. These additional approaches correspond to the utilitarian approach; the dynamic capability approach; and the market and material resource approach (see Chapter Three).
The proposed framework was used to investigate in particular the cropping strategic choice made by the ex-sugar beet farmers (ESBF) of the West Midlands region in response to the Sugar Regime reform (SRR). As a result of this reform, the sugar beet factory located in Allscott (ASBF) (i.e. the factory where the ESBF used to sell their production before the SRR) was closed and farmers were obliged to reformulate their cropping choices in order to adapt to the new business scenario. What is puzzling about this case is that data available from the public domain suggest that these farmers replaced sugar beet with traditional crops with low gross margin such as oilseed rape, wheat and barley in response to the closure of the ASBF (Clothier, 2010; and Department for Environment Food and Rural Affairs, 2010a). This is puzzling because there were other alternatives available with higher levels of gross margin such as carrots and parsnips and, as such, it raises a number of questions which this thesis will address. Why did these farmers choose crops with low gross margin? How did they make their cropping decisions? Which economic and non-economic factors were involved in the cropping decisions made by the ESBF? These questions cannot be answered by some research approaches which assume the existence of a representative farmer who seeks to maximise gross margin. The multivariate model proposed in this thesis, in contrast, was not only able to answer these questions, but also to predict heterogeneous behaviour across farmers and to predict behavioural patterns in terms of crop allocations that were validated empirically.

It is important to highlight the fact that the shock of the loss of the crop for this group of farmers is a rare occurrence. Consequently, the cropping decisions made by these farmers in the very short run may latter be modified. The purpose of this investigation is to use the proposed multivariate model to investigate, in particular, the initial choices made by the ESBF in response to closure of the ASBF. That is, the aim is to investigate
the initial farmers’ cropping decisions in the turbulent business environment caused by this particular shock.

The proposed multivariate model was also used to simulate the introduction of a policy programme consisting of a removal of material resource barriers (e.g. removal of capital constraints). While discussing policy and managerial implications of the findings is not an objective of this thesis, this simulation offered the opportunity to show how the model can be used to provide guidance to farm managers and policy makers in the design of strategies that could help farmers to sustain or even create competitive advantage.

In order to provide an overview of how this thesis was developed, this chapter is organised as follows. Section 1.2 explains how the research was conducted. Section 1.3 shows the structure of the thesis. Finally, Section 1.4 concludes the chapter.

1.2 Research Approach

An important observation made in the last section is that the following questions cannot be answered by some research approaches which assume the existence of a representative farmer who seeks to maximise gross margin: Why did these farmers choose crops with low gross margin? How did they make their cropping decisions? Which economic and non-economic factors were involved in the cropping decisions made by the ESBF?

The multivariate framework developed in this thesis, in contrast, can be used to answer these questions because it can predict theoretical heterogeneous behavioural patterns
across farmers under different conditions reflecting farmers’ cropping responses to policy changes. The advantage of this approach is that these behavioural patterns can be verified empirically. This is the research approach used in this thesis: theoretical behavioural patterns inferred from the proposed framework were formalised in eight hypotheses that constituted the research hypotheses of the current investigation. The empirical research strategy was designed with the objective of testing (accepting or rejecting) these hypotheses and, in this way, identifying the drivers that explain farmers’ cropping decisions. The purpose of this section is to describe how this research approach was implemented in this thesis.

1.2.1 The Pilot Investigation

A pilot investigation was conducted with the objective of facilitating the development of indicators that would form the questionnaire to be used in the present research. The method for the pilot consisted of two stages. In the first one, a number of farmers and some relevant agents that used to work in the NFU and the ASBF were interviewed using a semi-structured questionnaire. The objective of the interview was to gain an initial understanding of the way in which the ESBF adjusted to the closure of the ASBF. The information collected at this stage and the antecedents obtained from the literature were both used to design a draft version of the questionnaire that was subsequently used in the research. In the second stage of the pilot investigation this draft was pre-tested with ten ESBF.
1.2.2 The Static Stage of the Research

The static stage of the research was designed with the purpose of identifying the most relevant factors influencing the cropping choices made by the ESBF after the closure of the ESBF. This stage was named static because it focused on a single year to conduct the preliminary analysis. This year was 2008 and it was chosen as a relevant reference point because farmers had already internalised the shock caused by the closure of the ASBF in 2006.

The analysis was based on the proposed multivariate model. In particular, a novel economic theory associated with this framework was developed in this thesis. This theory was called the Multiple Efficient Frontiers Theory (MEFT) and was used to predict deviations from the assumed representative farmer’s behaviour when introducing non-economic drivers as variables explaining farmers’ strategic behaviour. These theoretical behavioural deviations were formalised as six testable hypotheses that are tested in one of the empirical chapters of the thesis (Chapter Six).

The advantage of this approach is that the validation of some of these hypotheses permitted the identification of specific economic and non-economic drivers that were involved in the farmers’ cropping decisions.

1.2.3 The Dynamic Stage of the Research

One of the most important findings of the static stage of the research is that the cropping choices of the ESBF were bounded by the existence of material resource restrictions such as capital. Because the removal of these restrictions is feasible (e.g. the
introduction of capital by means of policy programmes of local development), gaining an understanding of the way in which these farmers would adjust to a removal of material resource restrictions become a crucial task of the present research.

The objective of the dynamic stage of the research was to investigate the behavioural response of farmers to the removal of these restrictions. That is, the proposed multivariate model was used to simulate the introduction of a policy programme consisting of this removal. Two responses were predicted by the proposed multivariate model, and these predictions were formalised as two additional hypotheses that were tested in one of the empirical chapters of the research (Chapter Seven). In order to obtain data to test these hypotheses, an experimental method was adopted. In this method, farmers were asked to report the crops that they would choose and the proportion of land covered by these crops if they did not face material resource restrictions. This analysis was called dynamic because it compared the crop allocations reported in the experiment with the real allocations chosen in 2008 (i.e. the allocation of crops considered in the static stage of the research). Using this comparison, it was possible to identify a number of heterogeneous behavioural responses that were classified using a novel criterion called in this thesis the Income-Risk Matrix typology.

Using this typology, the farmers in the sample were classified in five different classes depending on the nature of the cropping choices they made in response to the removal of material resource restrictions. After that, statistical analysis was conducted to identify non-economic drivers (social-psychological variables) explaining why different classes of farmer adopted different strategic cropping choices. The results were used to propose a behavioural model that could be used to provide guidance to farm managers and policy makers who were faced with making decisions about how to adjust to shock in
their operating environments. It is contended that this modelling framework is applicable generally and not solely to the sugar beet sector.

1.3 Thesis Structure

To facilitate the understanding of the thesis structure and its aims, the contents of each chapter are described below.

Chapter Two provides the context of the study case. It starts by describing the macro policy reform of the Sugar Regime and its effects on the sugar beet sector in the West Midlands region. It also highlights the fact that the low gross margin choice made by the ESBF in response to the SRR cannot be explained by some research approaches which assume the existence of a representative farmer who seeks to maximise gross margin. The chapter ends by arguing that a better understanding of the way in which farmers make cropping strategic decisions requires a more holistic model that not only consider economic drivers, but also social-psychological considerations. A formal description of economic and social-psychological approaches that could potentially be integrated into this framework is presented in Chapter Three.

Chapter Three provides a literature review of different approaches that explain farmers’ strategic decisions and that can potentially explain the cropping choice made by the ESBF in response to the closure of the ASBF. These approaches are considered as key elements of the current investigation because they were integrated into a single multivariate model which is developed in Chapter Four.
Chapter Four explains the theoretical development adopted in the research. In particular, this chapter describes how the approaches identified in Chapter Three were integrated in the proposed multivariate model. It also analyses theoretical behavioural predictions made from this model. The chapter uses these predictions to propose eight hypotheses that constitute the research hypothesis established for the research.

Chapter Five describes the methodology used to test the eight hypotheses established in Chapter Four.

Chapter Six presents the results obtained in the pilot investigation and the static stage of the research. This chapter tests six of the hypotheses established in this thesis and provides an explanation for the low gross margin choice made by the ESBF in response to the SRR based on the results.

Chapter Seven presents the results obtained in the dynamic stage of the research. In particular, this chapter tests the remaining two hypothesis established in this thesis with the purpose of determining how farmers would adjust if material resource restrictions limiting their cropping choices were removed. It also describes managerial and policy implications of the findings.

Chapter Eight presents the conclusion of the research. Possible avenues for future research are also discussed.
Figure 1.1 shows a diagrammatic representation of the structure of the thesis. It illustrates each step undertaken and the way chapters are interconnected in the research process.

Figure 1.1 Outline and Structure of the Thesis

**Chapter One** introduces the aim of the research. It explains the academic gap and the way in which this gap has been filled.

**Chapter Two** provides the political context of the Sugar Regime reform and the impact on the farming activity in the West Midlands region.

**Chapter Three** reviews different approaches that could be used to explain the cropping choices made by the ESBF after the closure of the ASBF.

**Chapter Four** describes the theoretical development adopted in the research. It explains how the approaches identified in Chapter Three were integrated in the proposed multivariate model used in the investigation. The chapter also proposes the research hypotheses considered in this thesis.

**Chapter Five** describes the methodology used to test the research hypotheses proposed in Chapter Four.

**Chapter Six** shows the results obtained in the pilot investigation and in the static stage of the research.

**Chapter Seven** shows the results obtained in the dynamic stage of the research and discusses the political and managerial implications of the results.

**Chapter Eight** concludes the thesis and provides possible directions for future research.
1.4 Chapter Summary

This chapter provides an overview of the thesis. It opens by arguing that frameworks used to predict crop allocations in response to policy reforms normally adopt assumptions that oversimplify farmers’ behaviour. It then focuses on the fact that some of these frameworks assume the existence of a representative farmer who is assumed to maximise gross margin and draws attention to the limitations of such an approach. A driving fact behind this thesis is the concern that existing simplistic models have been proved to be ineffective and that a more complex and integrated modelling framework is needed to support strategic cropping decision making at both the individual farm and policy development levels.

The main objective of this thesis is to develop a holistic multivariate model with high predictive power that integrates different economic and social-psychological approaches to explain farmers’ strategic cropping decisions.

The proposed model was used to predict theoretical behavioural patterns that were formalised in eight testable hypotheses. In order to test these hypotheses, the model was applied to a sample of ex-sugar beet growers of the West Midlands region in the UK. Six of these hypotheses were analysed in the static stage of the research with the objective of identifying specific economic and non-economic drivers explaining the choice made by these farmers in response to the Sugar Regime reform (i.e. crops with low gross margin). The other two hypotheses were tested in the dynamic stage of the research which was designed to predict how these farmers would adjust if material resource restrictions faced by these individuals were removed.
The research developed in this thesis offers both novel academic and policy/practitioner contributions. The academic contribution comprises the holistic multivariate model to study farmers’ cropping decisions. This model constitutes a novel contribution because it can be used to identify heterogeneous cropping decisions and behavioural patterns across farmers in turbulent conditions (i.e. dynamic business environments) caused by policy changes. In contrast, some frameworks cannot predict heterogeneous behaviour because they rely on the assumption of the existence of a representative farmer. The proposed model also offers a richer description of farmers’ cropping decision making because it not only considers economic drivers as traditional frameworks do, but also social and psychological considerations. On the other hand, the policy/practitioner contribution of the research is that it provides a tool to policy makers and farm managers that can be used as guidance for the development of effective strategies (e.g. programmes of local development). This is because the proposed holistic model can be used to identify classes of farmers according to similar economic and social-psychological characteristics. This knowledge, in turn, can be used to design strategies with the purpose of inducing beneficial cropping decisions in response to future policy changes by farmers who fit within some of these classes.

Finally, it is important to keep in mind that the proposed model was developed with the purpose of studying the way in which farmers make their cropping decisions in dynamic business environments caused by policy reforms. It is for this reason that this thesis considers the case of the ex-sugar beet growers of the West Midlands region in the UK. As explained in the introduction, these farmers faced an important policy shock which corresponds to the Sugar Regime reform introduced by the European Union in January 2006. Consequently, studying the way in which these individuals adjusted to this reform offered the opportunity to apply the proposed holistic model and to test behavioural
predictions obtained from this model. Given the relevance of this study case for the current investigation, the macro policy context of the Sugar Regime reform and its effects on the cropping strategy adopted by the ex-sugar beet farmers are discussed in the next chapter. The next chapter also describes the academic gap identified from this study case, and proposes a number of research questions.
Chapter Two: THE CONTEXT OF THE STUDY: ESTABLISHING THE PROBLEM

2.1 Introduction

The sugar beet sector in the UK has traditionally been protected by what is called the Sugar Regime. This regime is part of the Common Agricultural Policy (CAP) of the European Union and provides direct and indirect support to different agents that form part of the supply chain of sugar. Sugar beet growers in the UK have been able to obtain a stable source of income from this crop because the regime establishes a guaranteed price for their production. However, this favourable business environment was negatively affected by the Sugar Regime Reform (SRR) which was formally adopted on 20th February 2006.

As a consequence of this reform, the sugar beet factory located at Allscott in the West Midlands was closed down. Farmers in this area were obliged to reformulate their cropping options in order to adapt to this important business environment change. These farmers opted for crops with lower levels of gross margin than other available alternatives such as parsnips and carrots, to replace sugar beet after the closure of the factory (Clothier, 2010; and Department for Environment Food and Rural Affairs, 2010a). There is a lack of information available which offers an explanation of why these individuals made this choice. Moreover, an empirical investigation conducted by the Rural Business Unit of the University of Cambridge and the Royal Agricultural College (2004) failed to predict the effects of the SRR on the cropping pattern in the West Midlands. Given that this research was based on the assumption that farmers were gross margin maximisers, this failure could indicate that factors other than maximising
The objective of this chapter is to describe the political context of the sugar beet sector in the UK. It opens with an overview of the operations of the UK sugar beet sector before the introduction of the SRR. The impact of the reform upon the sector in the West Midlands region is then outlined, and this is followed up by analysis of the response of the region’s farmers to this exogenous shock. This discussion of the impact upon the region’s farmers and their subsequent cropping choices, uncovers a number of research questions which are presented in the final part of the chapter.

2.2 The Sugar Sector in the UK

In the 1930s the sugar beet sector in the UK was a depressed sector and unable to compete with the cane refiners who imported raw sugar from the British Empire at a reduced tariff (Atkin, 2007). In order to promote the domestic supply of sugar beet, the government formally established a support system in the Sugar Industry Act of 1936. Under this act, eighteen beet factories were brought together to form the British Sugar Corporation Limited (BS), and financial assistance was given to growers of sugar beet. This act also included an agreement signed by cane refiners and beet processors which allocated a quota of 500,000 tons of sugar for beet factories corresponding to 26.3 per cent of the domestic consumption in 1933 (Competition Commission, 1981). Later on, during the World War II, the Ministry of Food applied administrative controls to the sugar industry by purchasing overseas and by establishing a long-term contract with Commonwealth suppliers. This contract was formally established under the 1951 Commonwealth Sugar Agreement. In practice, this agreement stimulated the cane sugar
industry of the Commonwealth and limited the domestic beet acreage for which BS might contract at the supporting price.

When the UK beet industry became part of the CAP Sugar Regime in February 1973, the government had to adopt the support method established by the CAP Sugar Regime. This consisted of a combination of policies used to maintain a guaranteed price of sugar in the domestic markets of the members of the Community. The most important polices were production quotas and price support. Each member of the Community was allocated its quota according to the amount of sugar it produced, and each sugar factory converted its quotas into delivery rights for each of its growers. Production within this quota received a price support (intervention prices or export refunds). For the UK, this quota had to represent half of the domestic consumption, and the deficit was met by imports of raw cane sugar from ACP countries (Catholic Institute for International Relations, 1994).

As a result of the adoption of the CAP Sugar Regime by the UK, the Commonwealth Sugar Agreement was not renewed in 1974 and this gave the beet industry the opportunity to expand. In fact, after the world shortage of sugar in 1974, the UK raised the beet sugar quota from 0.9 to 1.51 million tonnes, and the price paid on quota was raised by 15 per cent. BS had to carry out three main activities in order to achieve this expansion, namely: to expand its processing capacity for beet slicing and white sugar; to persuade farmers to increase the beet growing area and to achieve better yields per acre; and to encourage retailers and external buyers to buy its processed sugar (Competition Commission, 1981).
The expansion carried out by BS was coupled with a significant increase in the amount of domestic production of sugar beet a fact that is shown in Figure 2.1:

![Figure 2.1. Production of Sugar Beet in the UK (Source: Food and Agricultural Organization, 2010)](image)

As this figure illustrates, the production of sugar beet increased dramatically from 1973 to 1983 with the adoption of the Sugar Regime by the UK and stabilised at around 8 million tonnes during the second half of the 80s. From 1993, the annual production has oscillated, reaching a peak in production in the order of 13 million tonnes in 1997. These oscillations are mainly explained by the closure of some sugar beet factories in response to policy changes, and by increments of productivity (Clothier, 2010). For example, Bardney and Ipswich were closed in 2001 in response to the abolition of the storage aid system, and also as a consequence of the UK national quota reduction from 1.144 to 1.139 million tonne.
The adoption of the Sugar Regime in the UK not only increased the domestic production of sugar beet, but also caused an important geographical redistribution of this crop in the UK. Before the implementation of the SRR, the production of sugar beet was concentrated mainly in eastern regions of the UK. However, minor production of this crop was maintained in the West Midlands, as can be seen in Figure 2.2.

Figure 2.2 Distribution of Sugar Beet Production in the UK (year 2006). (Source: Clothier, 2010).
This distribution was determined by the location of the six BS sugar beet factories that were in operation before the reform, namely: Allscott, York, Bury St Edmunds, Cantley, Norfolk, and Newark-on-Trent and Wissington (Rural Business Unit of the University of Cambridge and the Royal Agricultural College, 2004). As shown in this figure, no production of sugar beet was carried out in areas located at a distance from these factories. This suggests that this business was only feasible for farmers operating near these factories. In this respect, UK Agriculture (2011) argues that sugar beet is a heavy and bulky crop, and this is why transport distances are kept as short as possible to reduce costs.

2.3 The Sugar Regime Reform (SRR)

The Common Agricultural Policy of the European Union (CAP) was subject to important criticisms during the 1980s and the 1990s. Firstly, the associated costs of traditional policy programmes included in the CAP were very high and absorbed about 75% of the total Community budget (Gardner, 2001). For example, at the end of 1970s the export subsidy of wheat was so large, that it equalled the world price of this commodity. Moreover, the surplus of some protected agricultural goods was so huge, that the Community was unable to dump it in world markets, even with the use of export subsidies. As a result, the Community had to use large amounts of money in order to storage this surplus. Secondly, the application of the CAP policies produced strong distorting effects on the wider economy. This is because these policies redistributed large amounts of income to farmers from both consumers and taxpayers, and this transfer created deadweight loss (Marsh and Swanney, 1980; and Demekas et al., 1988). In addition, the export of protected agricultural goods such as milk and cereals depressed the world prices negatively affecting the competitive position of
international competitors (Harvey and Thomson, 1985). Finally, environmentalists argued that the application of CAP policies negatively affected the environment in terms of creating problems for wildlife: hedge removal, wetland drainage, reclamation of rough grazing, and high nutrient levels in watercourses (Brassley, 1997). In response to these criticisms, three important CAP reforms were introduced: the MacSharry reform in the year 1992; Agenda 2000 reforms in the year 2000; and the 2003 CAP Reform Agreement or mid-term review. The main objective of the MacSharry reform was to promote development and competitiveness in the agricultural sector by replacing the old policies by compensatory payments and set aside practices in cereals, oilseeds, dairy products, beef, pigs and poultry. The objectives of Agenda 2000, on the other hand, were to correct some failures of the MacSharry reform and to introduce Rural Development. Finally, the main objective of the 2003 CAP reform was the introduction of important policies referred to as decoupled payments and cross-compliance regulations. The use of decoupled payments allowed the European Union to decouple compensatory payments of the CAP reform of 1992 into a Single Payment Scheme (SPS). The SPS was formally introduced on 1st January 2005 (Agra Europe, 2006; and Kelch and Normile, 2004).

Although the Sugar Regime was not directly affected by these reforms, the new policy orientation of the European Union (EU) in conjunction with a number of other factors, triggered a revision of the sugar policy. These factors, pointed out by Elbehri et al. (2008), are described as follows. Firstly, The EU agreed to eliminate tariffs on imported raw sugar from forty eighth of the least developed countries in what has been called Everything-But-Arms initiative. Secondly, the Sugar Regime was considered as violating the EU’s World Trade Organisation (WTO) export commitments. As a result, the EU had to stop exporting out-of-quota sugar making it not profitable to produce
sugar outside the quota system. Finally, the enlargement of the EU in 2004 led to revision which required compensation of third country exporters under WTO rules with additional current access quotas. As a consequence of this revision, the Sugar Regime was reformed and this reform constituted the most important change to the Sugar Regime in 40 years. The Sugar Regime Reform (SRR) was formally adopted on 20th February 2006 (Elbehri et al., 2008).

The main goal of the SRR was to eliminate the inefficiencies caused by the Sugar Regime. To achieve this purpose, three main objectives were defined: to promote a long-term policy perspective for the European Union sugar sector; to generate a competitive sugar sector in the European Union; and to meet the international commitments with the WTO. The reform package consisted of a price cut of 36% for processors and 40% for growers over four years (Bogetofi et al. 2007). In addition, compensatory payments referred to as Single Farm Payments were given to these farmers in order to compensate them for these price cuts (O’Brian, 2006). The trajectories of price cuts agreed at the November Council are shown in the following table:

### 2.1 Trajectories of price cuts

<table>
<thead>
<tr>
<th></th>
<th>2005/6</th>
<th>2006/7</th>
<th>2007/8</th>
<th>2008/9</th>
<th>2009/10</th>
<th>From 2010/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference price (price at consumer level) (\text{€/t})</td>
<td>631.9</td>
<td>631.9</td>
<td>631.9</td>
<td>541.5</td>
<td>404.4</td>
<td>404.4</td>
</tr>
<tr>
<td>Reference price at producer level (\text{€/t})</td>
<td>631.9</td>
<td>505.5</td>
<td>458.1</td>
<td>428.2</td>
<td>404.4</td>
<td>404.4</td>
</tr>
<tr>
<td>Reference price (raw sugar, ACP protoc.) (\text{€/t})</td>
<td>523.7</td>
<td>496.8</td>
<td>496.8</td>
<td>448.8</td>
<td>335.2</td>
<td>335.2</td>
</tr>
<tr>
<td>Minimum sugar beet price (\text{€/t})</td>
<td>43.6</td>
<td>32.9</td>
<td>29.8</td>
<td>27.8</td>
<td>26.3</td>
<td>26.3</td>
</tr>
</tbody>
</table>


BS adopted two important strategies in order to adjust in response to the SRR (Beverage Service Association, 2007). One of them was the closure of the factories.
located at York and Allscott. According to the Rural Business Unit of the University of Cambridge and the Royal Agricultural College (2004), the criteria for closing these factories relied on the fact that growers in these areas were the least efficient in terms of yields of sugar beet. In order to support this argument, these authors explain that the yields (tonnes per hectare) of sugar beet in Wissington, Bury St Edmunds, Cantley, Newark, Allscott and York in 2002 were 55.5, 55.2, 52.8, 52.7, 52.3, and 50.8, respectively. The second strategy was to allow farmers to trade their beet delivery rights among themselves. The aim of this was to prevent a dramatic decrease in the domestic production of sugar beet when paying the new minimum price (Revoredo-Giha et al., 2006).

2.4 The Effect of the Sugar Regime Reform on the West Midlands Region

Before the reform, the production of sugar beet in the West Midlands region was sustained mainly by the sugar factory located at Allscott (ASBF) which, according to statistics from Department for Environment Food and Rural Affairs (2010b), was supplied in 2006 by approximately 592 farmers corresponding to 8.3% of the total number of sugar beet growers in the UK in that year. The most important county in terms of the land given over to this crop in 2006 (i.e. before the closure of the ASBF) was Shropshire which is the area where the factory was located before the SRR. Other relevant areas were Worcestershire, Herefordshire, Staffordshire, and Telford and Wrekin. These five areas accounted for about 97.8% of the total area given over to sugar beet in the West Midlands (more general geographical characteristics of this region are presented in Appendix A). This is shown in Figure 2.3:
The two strategies adopted by BS to adjust in response to the SRR (see the discussion given at the end of the last section) had a negative impact upon the production of sugar beet in the West Midlands region, a fact that is formally shown in Table 2.2:

Table 2.2 Area of Land covered by Sugar Beet in 2006 and 2007.

<table>
<thead>
<tr>
<th>Region</th>
<th>Area (ha) in 2006</th>
<th>Area (ha) in 2007</th>
<th>Change of area</th>
<th>% of 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yorkshire and Humber</td>
<td>18,124</td>
<td>12,635</td>
<td>-5,489</td>
<td>-30</td>
</tr>
<tr>
<td>East Midland</td>
<td>27,056</td>
<td>26,876</td>
<td>-180</td>
<td>-1</td>
</tr>
<tr>
<td>West Midlands</td>
<td>11,676</td>
<td>6,687</td>
<td>-4,989</td>
<td>-43</td>
</tr>
<tr>
<td>Eastern</td>
<td>72,656</td>
<td>77,149</td>
<td>4,493</td>
<td>6</td>
</tr>
<tr>
<td>South East</td>
<td>57</td>
<td>600</td>
<td>543</td>
<td>953</td>
</tr>
<tr>
<td>South West</td>
<td>326</td>
<td>618</td>
<td>292</td>
<td>90</td>
</tr>
<tr>
<td><strong>England</strong></td>
<td><strong>130,135</strong></td>
<td><strong>124,994</strong></td>
<td><strong>-5,141</strong></td>
<td><strong>-4</strong></td>
</tr>
</tbody>
</table>

Source: Department for Environment Food and Rural Affairs (2010b)
The figures in this table indicate that the reallocation of beet delivery rights helped to mitigate the effects of the reform in the short-run. That is, the decrease of land covered by sugar beet in Yorkshire and the West Midlands regions was compensated by an increase of the land covered by this crop in the Eastern, South East and South West regions. From a regional point of view, however, this reallocation led to a huge decrease of the production of sugar beet in the West Midlands between the years 2006 and 2007. This strong negative effect on production is also shown in Figure 2.4:
A comparison between figures 2.2 and 2.4 reveals that the closure of Allscott led to a dramatic reduction in the area of land covered by sugar beet in the West Midlands region with a strong geographical contraction taking place in the areas at greater distance from Allscott.
2.5 Strategies adopted by the Sugar Beet Growers to adjust to the SRR

Data from the public domain suggest that the response of sugar beet growers to the changes wrought by the SRR, was to replace their sugar beet crops with crops with low gross margin such as oilseed rape, wheat and barley (Clothier, 2010; and Department for Environment Food and Rural Affairs, 2010a). This is a surprising response, given that these crops have low gross margins compared with other alternatives such as carrots and parsnips (see Table 2.3).

Table 2.3 Gross Margin and Standard Deviation for some Selected Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Gross Margin* (£/hectare)</th>
<th>Standard Deviation** (£/hectare)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberries</td>
<td>9,071</td>
<td>2,668</td>
</tr>
<tr>
<td>Raspberries</td>
<td>7,047</td>
<td>2,021</td>
</tr>
<tr>
<td>Carrots</td>
<td>6,869</td>
<td>2,127</td>
</tr>
<tr>
<td>Parsnips</td>
<td>5,347</td>
<td>384</td>
</tr>
<tr>
<td>Potatoes</td>
<td>1,925</td>
<td>289</td>
</tr>
<tr>
<td>Wheat</td>
<td>472</td>
<td>141</td>
</tr>
<tr>
<td>Oats</td>
<td>408</td>
<td>125</td>
</tr>
<tr>
<td>Barley</td>
<td>379</td>
<td>118</td>
</tr>
<tr>
<td>Oilseed Rape</td>
<td>294</td>
<td>119</td>
</tr>
</tbody>
</table>


It is not clear why these farmers chose crops which yield a low gross margin in response to the SRR. This could have been a short-term reactive decision which had the lowest uncertainty/risk and the lowest transaction costs in terms of adjusting to the SRR. In other words, this could reflect the fact that these individuals were not concerned with maximising gross margin at the moment of the closure of Allscott. This is indeed a possibility. An indication that this may have been the case, is found in the results of the academic work developed by the Rural Business Unit of the University of Cambridge.
and the Royal Agricultural College (2004). This investigation used a formal framework based on the gross margin maximisation assumption to estimate the possible effects of the SRR on the crop allocations in the West Midlands. For a 25% reduction in the intervention price and using 2002 as the reference year, the model predicted an increase in the area occupied by wheat, spring barley, winter barley, beans, peas, and potatoes. The model also predicted a small increase in the area covered by oilseed rape. However, these predictions are not consistent with the evidence. This is shown in Table 2.4 and Figure 2.5 which compare the area of land covered by key crops predicted by the model with data available in the public domain.

Table 2.4 Area of land (in hectares): predicted (25% cut in price simulation) and real (for year 2006), allocated to different crops in the West Midlands Region. Real and simulated change (in percentage) of the land allocated to these crops with respect to year 2002.

<table>
<thead>
<tr>
<th>Crops</th>
<th>Real</th>
<th>Simulation</th>
<th>Real change (%)</th>
<th>Simulated change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar Beet</td>
<td>11,676.0</td>
<td>11,313.0</td>
<td>-23.6</td>
<td>-26.0</td>
</tr>
<tr>
<td>Wheat</td>
<td>154,504.0</td>
<td>171,805.0</td>
<td>-4.9</td>
<td>5.7</td>
</tr>
<tr>
<td>Spring Barley</td>
<td>16,959.0</td>
<td>20,363.0</td>
<td>-15.0</td>
<td>2.1</td>
</tr>
<tr>
<td>Winter Barley</td>
<td>29,390.0</td>
<td>45,855.0</td>
<td>-35.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Beans and Peas</td>
<td>1,347.0</td>
<td>2,138.0</td>
<td>-17.5</td>
<td>30.9</td>
</tr>
<tr>
<td>Oil Seed Rape</td>
<td>34,419.0</td>
<td>23,152.0</td>
<td>49.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Potatoes</td>
<td>16,407.0</td>
<td>18,298.0</td>
<td>-9.5</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Source: Developed by the author with the statistics of Department for Environment Food and Rural Affairs (2010b) and the Rural Business Unit of the University of Cambridge and the Royal Agricultural College (2004).
Figure 2.5 Change of the land use for different crops: simulation (25% cut in price) and real change under a 20.6% cut in price in 2006 with respect to 2002. Source: developed by the author with the statistics of Department for Environment Food and Rural Affairs (2010b) and the Rural Business Unit of the University of Cambridge and the Royal Agricultural College (2004).

A simple Chi-squared test based on Table 2.4 revealed that the predicted and the real land allocations after the implementation of the SRR show no correlation. That is, the Chi-squared calculated was 5,511 and the value of the Chi-squared tabulated for 6 degrees of freedom considering 1% significant level is 16.81. As a result, the null hypothesis stating that there would be no differences between the real and the predicted land allocations for the crops considered in Table 2.4, was rejected at the 1% of significance level. If farmers did not act as gross margin maximisers, this casts doubt on the ability of a pure economic model to explain behaviour, and thus raises one of the central questions that this thesis will address: which factors can and do accurately explain crop choice?
Potentially, there are a number of factors that could explain why the sugar beet growers did not adopt crops with higher levels of gross margin. For example, if these farmers were risk averse, then they would have had an incentive to select crops with low gross margin because these agricultural goods also have low degree of business risk. To illustrate this, note that a common indicator of business risk used by economists is either the variance or the standard deviation of gross margin\(^2\) (Lien, 2002; and Hardaker et al., 1997). Table 2.3 above shows that crops with a high gross margin also have high levels of business risk (high standard deviation). Therefore, if these individuals were risk averse, then it would not be surprising that they chose crops with a low degree of risk.

However, there are other possible factors that could have influenced this choice. For example, lack of capital or lack of managerial capability can also affect cropping decisions. This is because crops with high gross margin are time demanding and they require the use of specific and expensive machinery. Lack of capital and lack of managerial capability have both been identified in the rural sector of the West Midlands region. For example, Ministry of Agriculture, Fisheries and Food (2000) argued that while farmers in this region have had clear opportunities to improve their business in terms of both turnover and employment, there is limited evidence showing that these individuals are involved in activities that can improve the marketing of food products, add value, or respond to changing market conditions.

The discussion developed so far suggests, therefore, that the decision making process of the sugar beet growers were influenced by a number of factors when the Allscott sugar

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\(^2\) Footnote 1 defines business risk as the aggregate effect of all the uncertainty influencing the levels of gross margin made by a firm. This definition suggests that changes in gross margin are caused by these effects. This is why the variance (or the standard deviation) of gross margin calculated over a period of time is used as a measure of business risk (Lien, 2002; and Hardaker et al., 1997). That is, because the variance captures quadratic deviations of gross margin with respect to the mean, it is assumed that this indicator captures quadratic deviations caused by the sources of uncertainty described in Footnote 1.
factory was closed. As a consequence, these individuals did not behave as gross margin maximisers when they faced this big exogenous shock. What it is not clear, however, is how these factors influenced the cropping strategy adopted by these farmers. This raises a number of research questions that are formally described in the next section.

### 2.6 Research Questions

To summarise the discussion developed above, it has been seen that sugar beet growers operating in the West Midlands region faced a big exogenous shock corresponding to the closure of the sugar beet factory located at Allscott. Available information suggests that these farmers adjusted to this shock by adopting crops with low gross margin such as oilseed rape, wheat and barley. A number of possible factors could have influenced this crop choice. However, little information is available in the public domain to help in identifying these factors. This is because little research has been developed which investigates farmers’ motivations and farmers’ decision making processes in response to the turbulent business environments caused by policy reforms. On the contrary, farmers’ cropping responses to policy changes have normally been predicted by adopting the *ad hoc* assumption of the existence of a representative farmer who only cares about maximising gross margin (although not all models adopt this assumption). This gap in the academic research raises a number of questions which this thesis will address:

1. Why did sugar beet growers choose crops with relatively low gross margin at variance with the expectations of economic theory?
2. How did farmers make these cropping decisions?
3. Which variables/factors influenced farmers in making these decisions?
4. How did farmers reconfigure their business strategies?
This research intends to address these questions by identifying the factors that influenced the cropping decision made by the sugar beet growers of the West Midlands region in the turbulent business environment caused by the closure of Allscott. This will be carried out through the integration of different approaches that could potentially explain farmers’ cropping decisions. For this purpose, a holistic model has been designed and this will be used to investigate the complex decision making process of these farmers during the unstable business environment caused by the reform. The next chapter reviews the approaches that were included in the integrating model, and Chapter Four describes this model in detail.

2.7 Chapter summary

This chapter has revealed a number of issues that are central to this thesis. First, it has been shown that the operational environment that the sugar beet farmers were accustomed changed quickly and significantly forcing them radically to rethinking their business and cropping decisions. Second, the predictive model developed by the Rural Business Unit of the University of Cambridge and the Royal Agricultural College (2004) was shown to be unrealistic and unreliable as a predictor of crop choice outcomes which in turn revealed that the assumptions that underpinned this model were underspecified and unrealistic. Third, the discussion revealed that the cropping choices made by the sugar beet farmers were counter-intuitive given the assumptions that they would seek to maximise gross margin by opting for crops with relatively high gross margin. Fourth, the analysis revealed that any predictive model would need to factor in criteria other than gross margin maximisation and simplistic economic assumptions and this framework has to be of any practical use to policy makers. This framework,
therefore, would need to be built using a more holistic approach. The rest of the thesis focussed on addressing these issues. The next chapter, in particular, reviews a number of alternative approaches that could potentially have been integrated with the purpose of developing a more complete and holistic model to explain farmers’ cropping decisions.
Chapter Three: ALTERNATIVE APPROACHES EXPLAINING FARMERS’ CROPPING DECISIONS

3.1 Introduction

Chapter 2 outlined how the ex-sugar beet growers in the West Midlands region (ESBF) adjusted to the closure of the Allscott sugar beet factory (ASBF) by replacing sugar beet with crops with low gross margins. As outlined in the previous chapter, it is not clear why these farmers adopted this strategy in response to their change in circumstances. As indicated, the existing models, based on the assumption of gross margin maximisation as the key driving factor, had low predictive validity.

This indicates a lack of predictive validity in existing models and calls for the development of different approaches to modelling farmers’ behaviour. In fact, a number of alternative and complementary approaches are available that could be used to attempt to explain this strategic choice involving crops with low gross margin. These approaches have been subdivided in two groups: approaches explaining individual behaviour (i.e. approaches that can be used to explain why individual farmers have replaced sugar beet with crops having low gross margin); and approaches explaining collective behaviour (i.e. approaches that can be used to explain why farmers have chosen the same crops to replace sugar beet in response to the SRR).

The approaches explaining individual behaviour correspond to different alternative theories or points of view that can be used to explain the cropping choice made by the ESBF in response to the closure of the ASBF. Five approaches were identified in the literature review developed in this chapter: (i) the dynamic capabilities approach in
which the choice made by the ESBF could be explained by the lack of opportunity to develop these capabilities in turbulent environments; (ii) the utilitarian approach in which the cropping choice made by these farmers could be explained by the fact that these individuals are risk averse; (iii) the multiple goals approach in which farmers make decisions that are influenced by goals other than maximising gross margin; (iv) the theory of planned behaviour in which farmers’ strategic behaviour is influenced by social-psychological variables; and (v) the market and material resources barriers approach in which the cropping choice made by the ESBF is explained by the existence of either market, capital, technological or land quality barriers that prevent them from choosing alternatives with higher levels of gross margin.

The approaches explaining collective behaviour correspond to other alternative theories or points of view that can be used to explain why the ESBF chose the same crops to replace sugar beet in response to the SRR. Only one approach was identified in the literature review. This is the institutional theory which postulates that individuals adopt similar strategies when their beliefs and norms are institutionalised (i.e. norms and beliefs are collectively accepted and given as granted).

The objective of this chapter is to review all these approaches, placing emphasis on their ability to potentially explain the cropping choice made by the ESBF after the implementation of the SRR. As these approaches provide alternative satisfactory explanations for this choice, the implication is that farmers’ strategic behaviour could be explained by all of these points of view simultaneously. They are therefore considered in Chapter Four as the basis for the proposed holistic multivariate model used in the present research.
It is important to highlight the fact that the approaches considered in this chapter are not completely independent. That is, there exist important overlaps among them. Consequently, using these approaches and ideas simultaneously without recognising overlaps could lead to misleading conclusions. This is why overlaps are formally described in Section 3.8.

To see how these approaches can simultaneously explain farmers’ cropping decisions, consider the following example. Consider the case of a sugar beet grower who is working in a family run business on a small/medium sized firm. He/she has been involved in sugar beet farming for the last thirty years and has detailed knowledge of the sugar beet industry and other areas such as wheat. He/she has invested heavily in sugar beet technologies and is farming Grade 3 agricultural land (see Table A2 in Appendix A). Suddenly, he/she is faced with a major shock to his/her business and he/she has to make choices not only about which crops to plant but major strategic choices about the direction of his/her business and how to run his/her business. He/she is faced by constraints of land quality, access to capital and his/her knowledge of growing crops with which he/she may not be familiar. He/she is also subject to other factors that will affect his/her business decisions: is he/she risk averse? Does he/she have the ability radically to reform or diversify his business? Is he/she motivated sufficiently to make disruptive strategic decisions? What will influence the decisions he/she makes? Is he/she prepared to behave cooperatively? Does he/she have access to good information to help him/her make these decisions? All these are factors which need to be taken into consideration when trying to explain farmers’ strategic decision making and this is the focus of this thesis.
3.2 Dynamic Capabilities Approach

Dynamic Capabilities (DC) are associated with the ability to integrate, reconfigure, renew and recreate resources in response to environmental changes in order to reach and sustain competitive advantage. According to some researchers, this ability depends on the existence of a number of determinants of DC such as capital, self-motivation, participation in social networks, etc. (Eisenhardt and Martin, 2000; and Wang and Ahmed, 2007). The DC approach can be used to understand why the ESBF have chosen crops with low gross margin by identifying which of these determinants were not available for these farmers. The strategy adopted in this thesis to obtain this information was the development of a model of DC based on the literature review presented in this section.

Before outlining this analysis, the section opens by providing a historical background to the area of strategic management. The objective is to provide the context of DC within the strategic business literature. In the second part of the section DC are formally reviewed. After that, the section uses this review to show how the absence of some key determinants of DC can explain the cropping decisions made the ESBF in response to the closure of the ASBF. It also provides some examples which illustrate how firms operating in other industries have chosen other strategies when some of these key determinants are available. The purpose is to show that the strategy adopted by firms in turbulent conditions can be influenced by the existence of these determinants of DC.
3.2.1 Historical Background to Strategic Management: contextualising Dynamic Capabilities

At a business level, the strategy of the firm is defined as “the match between its internal capabilities and its external relationships. It describes how it responds to its suppliers, its customers, its competitors and the social and economic environment within which operates” (Kay, 1993, p.4). It is also defined as the field that “deals with the major intended and emergent initiatives taken by general managers on behalf of owners, involving utilization of resources, to enhance the performance of firms in their external environments”, (Lynch 2009, p.6). This definition therefore indicates that strategy is concerned with the ability to sustain comparative advantage.

According to Rodrigues (2002), the first studies of organisational strategic behaviour appeared in the 1960s in a theoretical paradigm referred to as the classical approach. This approach assumes that agents are rational, logical and motivated by making profits and that they can achieve larger levels of profits by means of strategic initiatives. One seminal work in this tradition was that developed by Chandler (1962). This author found that managers of larger-size organisations had greater influence over the size and concentration of American industries than over other factors such as capital availability or entrepreneurial quality. This finding was used to support the idea that competitive markets do not adjust automatically as predicted by the “invisible hand” of Adam Smith. On the contrary, there is space for managers to influence competitive market outcomes by means of strategic behaviour (Chandler, 1977).

Ansoff (1957), on the other hand, proposed a method for measuring the profit potential of alternative product-market strategies. These strategies correspond to market
penetration (i.e. the strategy of maintaining the same products in the same markets); market development (i.e. the strategy in which the same products are located in new markets in terms of new segments, territories, uses, or new capabilities); product development (the strategy in which a firm introduces new products into existing markets); and diversification (i.e. the diversification strategy in which new products are developed and allocated into new related markets). These strategies are presented in Ansoff’s matrix in Figure 3.1:

<table>
<thead>
<tr>
<th>Market</th>
<th>Products</th>
<th>Existing</th>
<th>New</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. Product/build</td>
<td>Consolidation</td>
<td>With existing capabilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Market penetration</td>
<td>With new capabilities</td>
</tr>
<tr>
<td></td>
<td>C. Market development</td>
<td>New segments</td>
<td>With existing capabilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New territories</td>
<td>With new capabilities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New uses</td>
<td>Beyond current expectations</td>
</tr>
<tr>
<td></td>
<td>D. Diversification</td>
<td>With new capabilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beyond current expectations</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.1 Ansoff’s matrix. Source: Johnson et al. (2008).

During the 1980s, the strategy was re-conceptualised in terms of the application of industrial economic concepts. The most influential researcher in this period was Michael Porter who argued that the industrial organisation paradigm offers a way to measure competition and, therefore, this can be linked with the business policy of firms (Porter, 1981). According to Porter (1979), the state of competition of an industry depends on five forces: threats of new entrants; bargain power of consumers; bargain power of suppliers; threats of substitute products or services; and industry jockeying for position among current competitors. The author argued that these forces determine the profit potential of an industry. The strategy of a firm in this setting consists of finding a
position in the industry where it can best defend itself against these forces. In this context the ESBF had a privileged position in the industry provided by the political support of the Sugar Regime. This is because these farmers did not face threats of new entrants as they had formal delivery rights; they did not have to bargain for good prices because they were paid the supporting price which was already high; and this support was given only to sugar beet growers and not to growers of sugar cane.

The main characteristic of the research on strategic management in the 1960s and 1980s was, therefore, that it stressed the importance of external factors in determining the sources of competitive advantage. As a consequence, the analysis of environmental opportunities and threats developed much more rapidly than the analysis of firms’ internal strengths and weaknesses (Barney, 1995). Barney (1991) claims that this is because researchers adopted two simplifying assumptions that neglected the importance of internal analysis, namely: firms are identical in terms of the strategically relevant resources they control and the strategies that they follow; and resources used to implement the firm’s strategy are mobile which means, in practice, that any resource heterogeneity developed in an industry or group has a very short life. These assumptions eliminate any source of competitive advantage that could potentially arise as a result of either resource heterogeneity or resource immobility.

In the 1990s the emphasis changed from the analysis of the firms’ external environment to assessment of the organisation’s internal resources and capabilities (Leavy, 1996). An important academic contribution in this decade was the development of the Resource Based View (RBV) which, in contrast to the classical analysis, assumes both that firms within an industry may be heterogeneous with respect to the resource strategies they control and that these resources could be imperfectly mobile. Resources that are
heterogeneous across organizations and that can be sustained over time are the sources of competitive advantage or super-profits in equilibrium (Ambrosini and Bowman, 2009).

According to Barney (1991, 1995), these resources are valuable, rare, imperfectly imitable and non-substitutable (VRIN). Resources are valuable when they allow firms to implement strategies that improve its efficiency and effectiveness. A resource is rare when it is valuable and when it is possessed by a small number of firms. A resource is imperfectly imitable when firms that do not possess these resources cannot obtain them. Finally, a resource is imperfectly substitutable when there is no another strategically equivalent resource.

As an example, it was found in the present research that harvester machinery for sugar beet used to be a valuable resource because it not only provided the owners with productive efficiency, but also offered them the opportunity to expand their business by means of renting this machinery to other farmers. It was also rare because it was possessed by only a small number of farmers. According to the investigation, this was due to the fact that many sugar beet producers faced capital constraints. As a consequence, they were unable to afford the cost of buying this machinery given its high commercial price. Finally, the machinery was both imperfectly imitable and imperfectly substitutable because no other machinery was suitable to harvest sugar beet.

The RBV framework is presented in Figure 3.2:
The RBV has important drawbacks that make this framework unsuitable for the current research. Firstly, given its static nature, it fails to address the influence of dynamic business environments (Eisenhardt and Martin, 2000). That is to say, it is difficult to support the argument that firms can sustain competitive advantage by maintaining resources that are VRIN when environments are volatile and unpredictable. As a consequence, the RBV framework cannot be used to analyse how the ESBF adjusted to the turbulent environments caused by the reform of the Sugar Regime. Secondly, the RBV has failed to provide an explanation of the way in which resources are transformed to competitive advantage (Wang and Ahmed, 2007). As a result, this approach cannot be used to identify how farmers have acquired new resources, recombined and transformed resources in order to obtain comparative advantage.

In order to overcome these disadvantages, researchers developed an extension of the RBV which is referred to as dynamic capabilities. This extension is of great importance to the current research as it analyses strategic behaviour in dynamic and unstable business environments. Given the importance of dynamic capabilities for the current research, this topic is reviewed in detail in the next subsection.
3.2.2 Dynamic Capabilities

Dynamic Capabilities (DC) are an extension of the RBV which consider the evolutionary nature of resources and capabilities with respect to the business environment. Formally, DC are defined as “the firm’s processes that use resources – specifically the processes to integrate, reconfigure, gain and release resources – to match and even create market change. Dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve and die” (Eisenhardt and Martin, 2000, 1107). Some researchers argue that the ability to develop DC depends on a number of determinants such as capital and managerial skills, among others. This section describes in detail these determinants. The next section, on the other hand, shows how the low gross margin cropping choice made by the ESBF can be explained when some of these determinants are absent.

The central idea of DC is that resources can be integrated, reconfigured, renewed and recreated in response to environmental changes in order to reach and sustain competitive advantage. That is, they consist of strategies and organisational processes (e.g. alliances, strategic decision making, product development, etc.) that can be used to create value within dynamic markets by manipulating resources into new value creating strategies (Eisenhardt and Martin, 2000). Wang and Ahmed (2007), in a study based on empirical academic investigations, argue that DC are characterised by three components or factors that are common across firms: adaptive capability, absorptive capability and innovative capability. These terms are explained as follows.
Adaptive Capability (AC) is defined by Wang and Ahmed (2007), as “a firm’s ability to identify and capitalize on emerging market opportunities” (p37). An alternative definition is provided by McCann and Selsky (1984), who state that: “Adaptive capacity refers to both the amount and variety of resources and skills possessed by and available within a member’s environment for maintaining its viability” (p. 462). Researchers have identified three types of determinants of AC: organisational structures that help organisations to adapt (Moon et al., 2004; and Tushman and O’Reilly, 1996); material resources and the ability to exploit them (Chakravarthy, 1982); and contextual ambidexterity defined as “the set of processes systems that enable and encourage individuals to make their own judgments about how to divide their time between conflicting demands for alignment and adaptability” (Gibson and Birkinshaw, 2004, p210).

Absorptive Capacity or Capability (ABC), is defined as “the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends in order to innovate” (Cohen and Levinthal, 1990, 128). The knowledge considered in terms of external information corresponds to knowledge related to product or services, knowledge related to production processes, and knowledge related to markets (Van den Bosch et al., 1998). Cohen and Levinthal (1990) identified four sources of ABC: the ability to assimilate information as a function of the richness of the pre-existing knowledge structure (i.e. previous knowledge stock); the diversity of knowledge; the distribution of knowledge; and self-motivation. Van den Bosch et al. (1998) went on to identify two additional organisational determinants of ABC that are needed to facilitate the absorption of knowledge in turbulent business environments: organisation forms; and combinative capabilities.
Organisation forms are related to the organisation infrastructure and enable the process of evaluating, assimilating, integrating and utilising knowledge in a particular way. A functional form has a high potential for efficiency, but has a low flexibility for knowledge absorption. In contrast, a divisional form has a low potential for efficiency, but a high flexibility for knowledge absorption making this organisation more suitable for unstable business environments. Combinative capabilities, on the other hand, are defined as the ability to combine or integrate the individual capabilities of the members of an organisation.

Other determinants of ABC have also been identified. For example, Lenox and King (2004) introduced the concept of information provision which is defined as “the transfer of practice-specific data from a central knowledge repository (e.g. a corporate R&D lab) to agents within the firm that make technology adoption decisions” (P.332). These authors argue that managers can develop ABC by providing information through internal seminars, demonstrations, and promotional brochures. This transfer of information can help the organisation to reduce the search costs of new practices and to increase the likelihood of adoption. Chen (2004), on the other hand, argues that inter-firm alliances and collaboration across firms can help firms to acquire outside knowledge more effectively. In this context, Lane and Lubatkin (1998) found that the development of ABC is dependent upon relative similarities amongst the firms that form part of an alliance. These similarities are basic knowledge, shared research communities, and knowledge processing systems.

Finally, Innovative Capability (IC) is defined as “a firm’s ability to develop new products and/or markets, through aligning strategic innovative orientation with innovative behaviours and processes” (Wang and Ahmed, 2007, 38). Innovation, on the
other hand, is related to the creation of value by the application of knowledge in order to improve, change or develop specific activities (Edwards, et al., 2004). Different determinants of IC have been proposed. Zinger (1997), for example, argued that both technical and market experience have an important role in the success of output outcomes because experience prevents companies from replicating mistakes. Hagedoorn and Duysters (2002) argued that the formation of strategic alliances can help firms to increase market power, to enter new markets and increase the capabilities needed to innovate in new processes and products.

Macpherson et al. (2004) analysed the development of IC from a social network point of view. The authors argue that successful innovation in technological and managerial systems is based on managerial capabilities existing within the firm, and these internal capabilities can be increased by means of relationships within the supply chain. Empirical work has found that firms with a more active role in establishing inter-organisational relationships increase their chance of innovating (Chang, 2003; and Boahene et al., 1999).

Johnson et al. (2001), on the other hand, considered the use of innovation in products and services. They argued that communication quality, interpersonal communication and mediated communication are all important elements that determine the degree of involvement of individuals in innovation processes. Innovation involvement, in turn, corresponds to a mediating variable between communication and perceived innovativeness. Finally, perceived innovation is seen as a form of an organisation’s climate that drives to willingness to change. Finally, Delmas (2002) pointed out that IC is determined by two institutional factors: regulatory environment and attitudes toward
risk. The author found that there is less innovation when there are more institutional rigidities and when managers are more risk averse.

3.2.3 Dynamic capabilities and the ESBF

Let us now consider the case of the ESBF. One of the reasons that could explain why these individuals adjusted to the closure of the ASBF by selecting crops with low gross margin is because they did not have the ability to develop DC. For example, the availability of material resources has been identified as an important driver of DC because it contributes with the development of AC (Chakravarthy, 1982) and IC (Branzei and Vertinsky, 2006). The fact that the ESBF adjusted to the closure of the ASBF by selecting some crops with low gross margin suggests, therefore, that these individuals probably had a limited quantity of available material resources to develop innovation and diversification strategies. This could be explained, among others factors, by the existence of capital restrictions, a fact that has been noted by the Ministry of Agriculture, Fisheries and Food (2000). This can also be explained by the difficulty of producing efficiently crops with high gross margin as revealed by the results obtained by May et al. (2011d). This is because the productive process of these crops is very time consuming and requires the use of specific and expensive machinery that is not easy to obtain when facing capital constraints.

Another example that can be used to explain the cropping choice made by the ESBF is related to their pre-existing knowledge of the productive process of crops with high gross margin. As explained above, pre-existing knowledge stock is considered as a driver of ABC because it contributes with the absorption of related new information
(Cohen and Levinthal, 1990). Because ABC is a component of DC (Wang and Ahmed, 2007), lack of pre-existing knowledge could therefore prevent individuals from developing DC as this negatively affects their capacity to absorb new information. Considering this determinant of DC, it is also possible that the ESBF did not choose crops with high gross margin because they did not have pre-existing knowledge associated with the productive process of these crops.

Lack of participation in collaborative alliances can also explain in part the cropping choice made by the ESBF in response to the closure of the ASBF. This is because participation in collaborative alliances helps firms to acquire outside knowledge more effectively (Chen, 2004). According to Ministry of Agriculture, Fisheries and Food (2000), the formation of collaborative alliances is not common in the West Midlands. This was confirmed by May (2011) and May and Tate (2011) who found evidence revealing that most of the ESBF in their sample were not involved in collaborative alliances because they did not trust their potential partners. It is possible that this lack of collaboration has prevented the ESBF from obtaining relevant information on market opportunities related to alternative enterprises.

Regarding social networks, it is recognised that participation in formal and informal networks plays an important role in the development of IC in rural areas (Boahene et al., 1999). In particular, Virkkala (2007) found that small businesses in peripheral rural areas obtain relevant knowledge from their clients located in the region and from cooperation with other firms. The apparent lack of innovation by the ESBF in response to the closure of the ASBF suggests either that these agents were in general not involved with social networks or that the inter-farm information flow was poor. The results obtained by May et al. (2011a and 2011b) revealed that a significant number of ESBF
were actually involved with social networks suggesting that lack of innovation was due to the second reason. This factor can also explain in part the cropping choice made by the ESBF after the closure of the ASBF,

Regulation is another determinant of IC (Delmas, 2002) that could be used an example to explain the cropping choice made by the ESBF. In this respect, Dwyer et al. (2007) argued that the initiatives for innovation and sustainable rural development included in the last CAP reforms have not been sufficient to ensure their effective application. He claims that this is because these initiatives needed to be accompanied by institutional adaptation. It is possible that the ESBF were limited in terms of their capacity to innovate following the SRR because this CAP reform was not coupled with institutional adaptation. This might also reflect the fact that these farmers were not involved with policy bodies such as Department for Environment Food and Rural Affairs and National Farmers Union when the SRR was implemented.

Summarising this analysis, the literature on DC has offers potential explanations of the strategic decision and crop decisions made by the ESBF after the closure of the ASBF. According to this approach, a number of factors might have influenced these farmers’ choice of less innovative crops with low gross margin: a lack of capital; lack of relevant knowledge needed to innovate; and lack of participation in cooperative alliances and social networks, among others.

It should be noted, however, that this is only one possible explanation of the crop choices of the ESBF. As argued in the introduction of the chapter, other completely different approaches can also explain the crop allocations that were actually made. As a result, the framework based on the literature of DC can only provide a partial picture of
the complex relationship between farmers’ decision making and crop allocations. This further points to the concern that single approaches to explaining crop allocations have insufficient explanatory power and predictive accuracy and that a more integrated approach to framework development is needed. The development of such an integrated approach is a prime objective of this thesis.

3.2.4 Examples of Strategies adopted by Firms in Response to Exogenous Shocks

According to the review of the DC literature above, the strategies adopted by the ESBF after the implementation of the SRR depended partially on their ability to develop dynamic capabilities. If this is true, then it would be logical to expect that firms belonging to other non-agricultural industries (i.e. firms having different determinants of DC) would adopt different strategies. This would imply that DC are important determinants of farmers’ strategic decisions. In order to determine whether this can be verified, the following subsection reviews some examples of how firms belonging to different industries have adapted to exogenous shocks and which strategies they have chosen in the process.

3.2.4.1 Examples of strategies adopted by non-agricultural firms

Firms in different sectors have adopted many different strategies to adjust to exogenous shocks. The strategies firms have pursued can, however, be broadly classified into two types: those strategies that imply releasing firm’s resources (i.e. passive strategies associated with organisations having low opportunities to develop DC) and those strategies that imply reformulating the way in which existing resources are utilised (i.e.
active strategies associated with organisations having higher opportunities to develop DC).

Regarding the first group, Barker and Duhaime (1997) argued that passive strategies are normally adopted by firms belonging to declining industries or industries facing economic recession. They correspond to specialisation, cost saving, and mergers. Specialisation has been considered a useful strategy to adopt in dynamic environments because economic shocks increase managerial and organisational costs, and this can negatively affect the profitability of diversification (Chakrabarti et al., 2007; and Lubatkin and Chatterjee, 1994). As a result, firms that specialise in enterprises having core competences release slack resources (i.e. human and physical resources). This, in turn, allows them to save costs and to improve administration efficiency (Dewitt, 1998). This was confirmed by Lee and Lee (2007) who found that after the Korean crisis, Samsung’s strategy was to close the automobile manufacturing enterprise.

Cost saving strategies, on the other hand, correspond to strategies that firms choose to adjust in the short run by releasing resources associated with variable costs (e.g. labour). That is, they are primarily reactive and defensive strategies in that they are often not about developing new products and markets or about innovation, but about rationalisation and cost reduction. For example, Health Financial Management Association (2009) argued that hospitals in the United States reduced staff and froze salaries in order to accommodate to the current recession.

Finally, mergers are strategies in which firms merge with the purpose of reducing costs by changing their operational scale. For example, Behar and Hodge (2008) studied the declining South African gold mining industry and found that firms in this industry
merged in order to survive and that strategy was accompanied by a reduction of the number of worker employed.

Active strategies, on the other hand, have been adopted in the form of strategy flexibility, diversification, formation of networks, and formation of collaborative alliances. Strategic flexibility is related to the flexibility of product creation resources. According to Sanchez (1995), this flexibility “...depends jointly on the resource flexibility of the product creation resources available to a firm and (2) the coordination flexibility of the firm in using its available resources in product markets” (p. 135). This implies that strategic flexibility is a term that involves both the use of existing resources for alternative targets without incurring in significant costs, and activities that coordinate organisation structures in order to support firms’ product strategies. For example, the same author found that firms that have successfully survived in dynamic environments have adopted technological innovation in modular product design and CADD/CIM systems. They have been successful because these technological innovations inspired managerial innovations in coordinating flexible resources. As a consequence, new product strategies and organisational structures were implemented. Likewise, Filatotchev and Toms (2003) found that some UK textile firms were able to stay in business after the introduction of the Cotton Industry Act in 1962 by means of the development of new product strategies and organisational structures (e.g. product differentiation, vertical integration, number of independent plants, and organisational diversity, among others).

Diversification, on the other hand, has also been used as an active strategy to adapt to exogenous shocks. According to Froelich and McLagan (2008), the type of diversification that is more beneficial in dynamic environments is diversification into
related fields because by taking place in more similar areas it is possible to keep diversification cost low. The authors supported their argument using the electrical power industry in the United States as a study case. Firms in this industry responded to deregulation by diversifying within the electrical utility industry. A similar example is provided by Muller et al. (2008) who found that as a consequence of the creation of the single European electricity market by the European Commission in 1998, German companies were able to overcome the associated loss of market power by successfully diversifying into related activities such as telecommunications, cable TV, public lighting, heat, gas, water and sewage. Likewise, Hitt et al. (2007) showed that large US law firms developed a successful diversification strategy into related legal services after the market for corporate legal services became more competitive.

Evidence also shows that some firms have diversified with the objective of increasing returns and to reduce risk in dynamic and unstable business environments. That is, in order to reduce the risk of the portfolio of goods and services supplied by firms (Berger and Ofek, 1995). For example, this strategy has been detected in the pharmaceutical sector. According to Grewal et al. (2008), pharmaceutical firms have turned to portfolio management in order to develop new products, and to maintain long term profitability in risky industry environments.

The formation of networks is another active strategy that has been used to adjust in dynamic environments. An example of this is in New Zealand where, as a response to the development of structural agricultural reforms during the 80s and 90s, dairy farmers formed social networks in order to overcome the risk arising from this reform. The formation of social networks helped these individuals to access high quality information
that was useful to enhance learning strategies to avoid or reduce risk to the extent possible (Sligo and Massey, 2007).

According to Koka and Prescott (2008), however, firms operating in different business environments require different capabilities to maintain competitive advantage. A particular network structure, in turn, provides capabilities that are useful in a particular business environment. As a result, a change in the environment caused by the incidence of a shock implies that the existing capabilities are no longer of use in maintaining competitive advantage. Hence, in order to develop capabilities that are consistent with the new business environments, firms need to modify their network relationships. The authors supported this idea using the steel industry as a study case. They found that as a result of the incorporation of policy reforms in USA in the 1980s (e.g. the relaxation of antitrust laws), firms in the steel industry changed their network structure.

Finally, collaboration and the formation of inter-firm alliances are also active strategies that have been adopted with the objective of adjusting in dynamic environments because they help firms to break market barriers in response to exogenous shocks. An example of this is the emergence of biotechnology which constituted an important innovation which increased the barriers of entry to the pharmaceutical industry (Lee, 2007). This change in the business environment motivated firms to collaborate in investment expenditure in order to develop R&D. According to Valentinov (2005), alliances can also be formed to break market barriers that are supported by power imbalance in the relationship between suppliers and retailers. This is due to the fact that these alliances develop countervailing power.
The strategies revised in this section are summarised in Table 3.1.

Table 3.1 Strategies adopted by Firms to adjust to Exogenous Shocks

<table>
<thead>
<tr>
<th>Type of strategy</th>
<th>Strategy</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive</td>
<td>Specialisation</td>
<td>Specialisation in core competences</td>
</tr>
<tr>
<td></td>
<td>Cost saving</td>
<td>Change in variable costs</td>
</tr>
<tr>
<td></td>
<td>Mergers</td>
<td>Change of scale operation</td>
</tr>
<tr>
<td>Active</td>
<td>Strategy flexibility</td>
<td>Resources and coordination flexibility</td>
</tr>
<tr>
<td></td>
<td>Diversification</td>
<td>Reduce cost and/or business risk</td>
</tr>
<tr>
<td></td>
<td>Networks</td>
<td>Capabilities to maintain competitive advantage</td>
</tr>
<tr>
<td></td>
<td>Alliances</td>
<td>Break market barriers</td>
</tr>
</tbody>
</table>

(Source: Author’s own)

3.2.4.2 The strategies identified in the examples and the ESBF

The analysis described above shows that different firms in different sectors have chosen different strategies in response to exogenous shocks (see Table 3.1). This suggests that the types of strategies adopted by firms in dynamic environments are indeed associated with some specific determinants of DC (or with the lack of some determinants of DC). This reinforces the idea that the ESBF could have chosen crops with low gross margin because these agents faced barriers that prevented them from developing their DC.

To see why this could be the case in the context of the strategies described in Table 3.1, note first that farmers normally produce two or more crops each year. That is, each year they form portfolios of crops that are compatible with their existing agricultural machinery and stock of capital. Considering these portfolios, the reform of the SRR could have motivated farmers to specialise by increasing the area of land covered with one of the crops included in their portfolios before the reform in order to replace sugar.
beet. This is a possibility because diversifying their cropping plans by means of the inclusion of non-traditional alternatives (e.g. carrots and parsnips) implies the acquisition of very expensive and specific machinery. Thus, if a farmer faced capital restrictions preventing him/her from adopting this machinery, he/she could specialise in crops that are compatible with her/his existing stock of capital.

Related diversification, would also be a suitable strategy for the ESBF because replacing sugar beet with crops that are compatible with their existing machinery can help them to adapt without incurring in additional cost. This might actually reflect the apparent strategy adopted by these farmers because the machinery used to produce oilseed rape, wheat and barley (i.e. the crops that apparently were adopted by the ESBF to replace sugar beet as suggested by Clothier, 2010; and Department for Environment Food and Rural Affairs, 2010a) is compatible with that used in cereals, and the latter are crops that have typically been produced in the West Midlands region (see Tables B1 and B2 in Appendix B).

Cost saving strategies, on the other hand, are not suitable for the case of the ESBF to adjust in the short run because this strategy implies only modifying variable costs in this horizon of time (e.g. seeds and agricultural labour) without actually changing the productive plan. Clearly, modifying variable costs without eliminating the production of sugar beet was not an option for the ESBF given the closure of the ASBF. This is because this closure implied that no relevant markets for sugar beet were available in the West Midlands region after the reform.

\[\text{It is important to note, however, that farmers could eventually save costs by changing fixed costs in the medium-long run. For a discussion, see Jehle and Reny (2001).}\]
With respect to merger strategies, it remains unclear whether farmers would be willing to merge their farms. This is because farmers in UK operate mainly on a family basis (Lobley, 2010), and it is probable that for a number of them continuing the tradition of the farm as a family-owned business was of great importance. In this case, a more suitable strategy would be the formation of cooperative alliances because they would help farmers to modify their operational scale by sharing machinery, costs and area of land without altering their family identity.

The formation of networks is also a suitable strategy for farmers in general because they could form networks in order to obtain relevant information to innovate in dynamic environments. However, it is difficult to argue that the ESBF used networks to innovate in response to the implementation of the SRR because they chose crops with low gross margin after the incorporation of the SRR.

Finally, it is not clear whether farmers can adopt strategy flexibility because agricultural resources such as machinery are generally specific to some crops. This could explain why most of the ESBF chose crops with low gross margin to replace sugar beet.

### 3.3 The utilitarian approach

Another theoretical point of view that could help explain the cropping choice made by the ESBF at the individual level is the utilitarian approach. Basically, this approach argues that individuals do not only consider gross margin when making their strategic decisions, but also the associated business risk (this concept is formally defined in Foot 1 in Chapter One). The reason this approach could offer an explanation for the cropping
choice made by the ESBF is because these individuals were obliged to adjust in the turbulent and riskier condition generated by the SRR. In this context, risk aversion behaviour could have played a key role in shaping the way in which these individuals responded to this political shock.

As the utilitarian approach is an extension of the gross margin maximisation paradigm, the section starts by providing a brief description of the latter with the objective of contextualising the utilitarian approach within the economic literature. The second part of the section describes the utilitarian approach in detail. Finally, the way in which this approach can be used to explain the cropping choice made by the ESBF at the individual level is considered.

3.3.1 The Gross Margin Maximisation Paradigm

The gross margin maximisation paradigm establishes that farmers allocate crops in order to maximise gross margin, where gross margin is defined as the difference between total revenue and total variable costs of different farm enterprises (some academic works have developed related frameworks considering profit maximisation rather than gross margin maximisation. See for example Bulte et al. (2007); and Schuler and Kächele (2003)). This approach assumes that this maximisation is constrained by the productive technology used in the farm and that forward prices are known. A simple example of a multicrop model based on gross margin maximisation is shown as follows:
\[
\max GM = P_i Q_i + P_j Q_j + P_k Q_k - TVC(w_1, w_2, \ldots, w_n)
\]

Subject to

\[
TB(\alpha_1, \alpha_2, \ldots, \alpha_n)
\]

Where \( GM \) denotes total gross margin; \( \max GM \) corresponds to the objective of maximising gross margin; \( P_i Q_i \) is total revenue obtained from crop \( i \); \( P_i \) and \( Q_i \) are price and output of crop \( i \), respectively; \( TVC \) is the total variable cost incurred in the production of crops \( i, j \) and \( k \); \( w_n \) is the unitary cost of input \( n \); \( TB \) denotes the productive technology or technical barrier; and \( \alpha_n \) denotes the technological coefficient of input \( n \).

This traditional framework (or related versions) has broadly been used in the agriculture sector since the 1930s (see for instance Schultz, 1939; and King, 1953), and is still being used to study different situations associated with the rural world (see Raper et al., 2007; Bulte et al., 2007; Hueth and Marcoul, 2006; and Yang and An, 2002). For example, an exogenous technological shock such as the introduction of hybrid seeds can be modelled as an increase in the \( \alpha \) coefficients in the technological barrier function. This is because hybrid seeds allow farmers to increase production by using the same levels of inputs. An exogenous shock introduced by a policy reform, on the other hand, can be modelled as either an exogenous change in the prices of inputs or outputs.

Even when gross margin maximisation (and the alternative version of profit maximisation) has broadly been used to study different situations in agriculture, its applicability has been questioned over a long period of time because it oversimplifies the way in which farmers make their decisions (Gasson, 1973; and Halter and Beringer, 1960). In practice, this oversimplification can lead to poor predictions of crop
allocations. For example, oilseed rape is a good break crop from wheat as was sugar beet. Consequently, adopting this crop to replace sugar beet could be considered as a rational choice that not necessarily implies maximising gross margin.

It is worth pointing out that gross margin maximisation could be considered as a good approximation of farmers’ behaviour in stable business environments (i.e. pre-reformed environments). However, in contrast, business risk could constitute a relevant variable affecting farmers’ strategic behaviour in turbulent business environments (i.e. post-reformed environments). Hence, if the environment became turbulent as a consequence of a policy reform, then simulations made in pre-reformed environments assuming gross margin maximisation could generate poor predictions of post-reformed conditions because they did not consider the associated business risk. This can explain, for example, why the framework developed by the Rural Business Unit of the University of Cambridge and the Royal Agricultural College (2004) produced poor predictions of crop allocations after the SRR (see Section 2.3). This weakness of the gross margin maximisation paradigm has motivated researchers to introduce different extensions, with the utilitarian approach being one of them. This is outlined below.

### 3.3.2 The utilitarian approach

The utilitarian approach is an extension of the gross margin maximisation paradigm and was developed with the objective of introducing business risk as an explanatory variable of farmers’ decision making (Edwards-Jones, 2006). This approach assumes that risk averse farmers form portfolios of crops in order to maximise an expected utility function that depends positively on the expected gross margin and negatively on either
the variance or standard deviation of gross margin as an indicator of business risk (Footnote 2 in Chapter Two formally explains why the variance (or standard deviation) has been used as indicators of business risk). In other words, individuals are assumed to be expected-utility maximisers. That is, this approach assumes that risk averse farmers are willing to sacrifice expected gross margin in order to reduce total business risk.

Originally, the purpose of using this extension was to explain why some farmers in the 1950s and 1960s chose riskier agricultural enterprises than others (Halter and Beringer, 1960). Researchers at that time postulated that differences in productive plans between farmers would be attributable to differences in their attitudes toward risk. In order to attempt to prove this hypothesis, researchers used empirical experiments to determine whether farmers were indeed risk averse individuals. In the 1960s they were able to confirm this hypothesis, and used this result to argue that these individuals were expected-utility maximisers (Halter and Beringer, 1960; and Johnson, 1962). This means that these farmers simultaneously maximised the expected gross margin and minimised the associated business risk of their productive plans when making their optimal cropping decisions. Later on, researchers developed formal mathematical optimisation frameworks assuming the existence of a representative expected-utility maximiser farmer to predict farmers’ responses to policy reforms and changes in market conditions (Gomez-Limon et al., 2003; Lien, 2002; Hardaker et al., 1997; Lin et al., 1974; and Officer and Halter, 1968). These mathematical optimisation models are the frameworks used at present and, given their relevance for the current research, they are explained below.

Mathematical optimisation frameworks assume the existence of a representative expected-utility maximiser and are based on two important theoretical developments.
referred to as the Subjective Expected Utility hypothesis (SEU) and the Mean-Variance Analysis (EV). Given the importance of these developments for the present thesis, they are explained in detail in the following subsections.

3.3.2.1 The Subjective Expected Utility hypothesis (SEU)

The SEU was developed by John von Neumann and Oscar Morgenstern in 1947 and postulates that economic decisions under uncertainty are gambles in which each possible outcome or state of nature is associated with a particular level of utility and a particular probability of occurrence. The associated utility function, \( U(\pi) \), is referred to as the Bernoulli utility function, where \( \pi \) in the agricultural context denotes gross margin. The von Newman-Morgenstern’s hypothesis says that agents make their decisions under uncertainty by comparing the Bernoulli utility function with an expected utility defined as 

\[
E(U(\pi)) = \theta_L U(\pi_L) + (1-\theta_L) U(\pi_U),
\]

where \( \theta_L \) is the probability of outcome \( \pi_L \) and \( 1-\theta_L \) is the probability of outcome \( \pi_U \). These concepts are explained in more detail as follows.

In order to understand how the SEU can be used to explain the way in which individuals make decisions under uncertainty, it is important to clarify the difference between the Bernoulli utility function, and the expected utility function. The Bernoulli utility is the traditional utility function used to show how individuals’ level of utility increases as they achieve higher levels of gross margin (i.e. \( U(\pi) > U(\pi') \) for all \( \pi > \pi' \)). This function can be concave, convex or linear depending on the individual under consideration. That is, for some individuals this function is concave, for others is convex, and for others is linear (see Morgan et al., 2006). As explained below, this
depends on individuals’ attitudes toward risk. Figure 3.3 shows the Bernoulli utility function for three different individuals.

Figure 3.3 Bernoulli Utility Functions.

Figure 3.3(a) shows the case of an individual who has a concave utility function. In this case, the utility of this individual increases at a decreasing rate (i.e. the increments of utility are smaller for higher levels of gross margin). For this individual, losing a determined amount of gross margin generates a higher loss of utility than the gain in utility when he/she obtains a similar amount of gross margin. An example of this utility function that has been used for empirical and theoretical research is the logarithm utility function (Jehle and Reny, 2001): $U(\pi) = \ln(\pi)$, where $\ln$ denotes natural logarithm.

Figure 3.3(b), on the other hand, shows the case of an individual who has a convex utility function. The main characteristic of this function is that the utility of this individual increases at an increasing rate (i.e. the increments of utility are larger for higher levels of gross margin). An example of this function is the quadratic utility function.
function (Jehle and Reny, 2001): $U(\pi) = a + b\pi + c\pi^2$. Finally, Figure 3.3(c) shows the case of a linear utility function. In this case the individual’s utility increases at a constant rate when gross margin increases. An example of this utility is given by: $U(\pi) = \pi$ (adapted from Alesina and Tabellini, 2007).

On the other hand, the expected utility function, $E(U(\pi))$, in the context of the SEU is a linear function because it is defined as a linear combination of specific values of the Bernoulli utility associated with different states of nature. That is, it is a weighted average of the levels of utility that an individual can obtain in different states of nature, where the weights are defined as the probability of occurrence of these states of nature. For simplicity and without losing generality, two states of nature will be considered to explain this concept: the state of nature with low gross margin, $\pi_L$, defined as the state in which the individual obtains $\pi_L$ with probability $\theta_L$ (this state of nature is referred to in this thesis as the unfavorable state of nature); and the state of nature with high or upper gross margin, $\pi_U$, defined as the state in which the individual obtains $\pi_U$ with probability $1 - \theta_L$ (this state of nature is referred to in this thesis as the favorable state of nature). To help in the understanding of the concept of expected utility, remember that the expected utility function was defined as $E(U(\pi)) = \theta_L*U(\pi_L) + (1-\theta_L)*U(\pi_U)$. This is the weighted average of the levels of utility obtained from the Bernoulli utility function in the favorable and unfavorable states of nature (i.e. $U(\pi_L)$ and $U(\pi_U)$, respectively) weighted by their probabilities of occurrence (i.e. $\theta_L$ and $(1-\theta_L)$, respectively). Thus, if the Bernoulli utility function is concave (see Figure 3.3(a)) and equal to $U(\pi) = Ln(\pi)$, then the expected utility function becomes $E(U(\pi)) = \theta_L*Ln(\pi_L) + (1-\theta_L)*Ln(\pi_U)$. In contrast, if the Bernoulli utility is convex (see Figure 3.3(b)) and equal to $U(\pi) = a + b\pi + c\pi^2$, then the expected utility becomes $E(U(\pi)) = \theta_L*(a + b\pi_L + c\pi_L^2) + (1-\theta_L)*(a + b\pi_U + c\pi_U^2)$. Finally, if the Bernoulli utility is linear (see Figure 3.3(c)) and equal to $U(\pi) = \pi$,
then the expected utility becomes \( E(U(\pi)) = \theta_l \pi_l + (1-\theta_l) \pi_u \). In order to clarify the concepts of Bernoulli utility and expected utility functions, and how they are related, a formal numerical example is presented in Appendix C.

The SEU assumes that individuals compare the expected utility function with the Bernoulli utility function to make decisions when facing uncertainty because they have to make expectations about future possible outcomes. For example, consider a person who faces two states of nature when going to the supermarket: losing wealth (i.e. achieving \( \pi_l \)) as a consequence of a car accident; and maintaining the same wealth if there is no accident (i.e. achieving \( \pi_u \)). If the probability of a car accident is high (i.e. \( \theta_l \) is closed to one), then the individual will probably decide not to go to the supermarket (under the assumption that this individual is risk averse). In contrast, if the probability of a car accident is closed to zero, then the individual will probably go to the supermarket. This example shows that the decision of going to the supermarket depends on two factors: (i) the individual’s expectations about the occurrence of the state of nature car accident; and (ii) the individual’s attitude toward risk. As shown below, expectations about states of nature (or future outcomes) are associated with the expected utility function, and attitudes toward risk are associated with the Bernoulli utility function. This if formally explained as follows.

In order to explain how individuals make decisions under the SEU, consider the example shown in Figure 3.4. This figure shows two individuals, one who has a concave Bernoulli utility function defined by points \( c, b, \) and \( d \) in Figure 3.4(a); and one who has a convex Bernoulli utility function defined by points \( c, a, \) and \( d \) in Figure 3.4(b). These figures also show the associated expected utility functions. For the individual who has a concave Bernoulli function, his/her expected utility is defined by
points $c$, $a$ and $d$ in Figure 3.4(a). Likewise, the expected utility of the individual who has a convex Bernoulli utility function is defined by points $c$, $b$ and $d$ in figure 3.4(b).

Figure 3.4 Relationship between the Bernoulli Utility Function and the Expected Utility Function.

Note that the expected utility functions of both individuals are equal to their Bernoulli utility functions at points $c$ and $d$. The reason is because these points represent points of certainty. To see that, remember that the expected utility function is defined as $E(U(\pi)) = \theta_L U(\pi_L) + (1-\theta_L) U(\pi_U)$. Thus, if the outcome $\pi_L$ is verified with certainty (i.e. when $\theta_L = 1$), then this equation converges to $E(U(\pi)) = U(\pi_L)$. That is, when $\pi_L$ is verified with certainty, the expected utility is equal to the Bernoulli utility at the level of gross margin equal to $\pi_L$. This is why both functions intersect at point $c$ in Figures 3.4(a) and 3.4(b). The same is valid when outcome $\pi_U$ is verified with certainty (i.e. when $1 - \theta_L = 1$). In this case, the expected utility function and the Bernoulli utility function intersect at point $d$ in Figures 3.4(a) and 3.4(b). However, when individuals have a degree of uncertainty (i.e. when $0 < \theta_L < 1$), then both utility functions report different levels of utility and this occurs between points $c$ and $d$ in Figures 3.4(a) and 3.4(b). In other words, uncertainty is presented in the geometric space defined by these two points. For
the explanation that follows, this geometric space is referred to in this thesis as the “uncertainty space”. It is in this space where individuals have to make decisions under uncertainty from the SEU point of view. This is explained as follows.

According to Figure 3.4(a), the Bernoulli utility function $U(\pi)$ reports higher utility than the expected utility function $E(U(\pi))$ for any level of gross margin $\pi^*$ in the range $\pi_L < \pi^* < \pi_U$. In other words, the Bernoulli utility function reports higher utility than the expected utility function $E(U(\pi))$ in the uncertainty space. To understand the implications of this, let us consider the example given in Appendix C. In this example, it was assumed that $\pi_L = 10$ and $\pi_U = 40$ (see Table C.1). Suppose in addition that both individuals represented in Figure 3.4 believe that the outcomes $\pi_L$ and $\pi_U$ have probabilities of occurrence equal to 0.4 and 0.6, respectively (this case is presented in the second line of Table C.2). The expected gross margin that these individuals can obtain under uncertainty is therefore equal to $\pi^* = \theta_L \pi_L + (1-\theta_L) \pi_U = 0.4 \times 10 + 0.6 \times 40 = 28$. Because this level of gross margin is obtained under uncertainty (i.e. it is an expected gross margin), the individuals have to make expectations about the possible level of utility that they can achieve from this gross margin. That is, the individuals have to consider the expected utility function which reports an expected level of utility equal to $E(U(\pi^*))$ rather than the Bernoulli utility which reports a certain level of utility equal to $U(\pi^*)$. Suppose now that the individual presented in Figure 3.4(a) is given the chance to receive $\pi^* = 28$ with certainty. In this case he/she obtains the utility reported by the Bernoulli utility given by $U(\pi^*)$ because this gross margin is obtained with certainty. The fact that $U(\pi^*) > E(U(\pi^*))$ when the Bernoulli utility function is concave (i.e. the case presented in Figure 3.4(a)) means that the individual obtains a higher level of utility when $\pi^* = 28$ is given to him/her with certainty. This is why individuals who have a concave Bernoulli utility function are said to be risk averse. Unfortunately for
risk averse individuals, it is not always possible to eliminate uncertainty in the real world (e.g. volatile prices of commodities). However, these individuals can still reduce uncertainty by adopting different strategies such as diversifying production or by contracting insurance, among others.

The opposite is shown in figure 3.4(b). Because in this case the Bernoulli utility function reports a lower level of utility than the expected utility function for any level of gross margin \( \pi^* \) in the range \( \pi_L < \pi^* < \pi_U \) (i.e. \( E(U(\pi^*)) > U(\pi^*) \)), it indicates that this individual prefers to obtain this level of gross margin under uncertainty. This is why this individual is said to be risk lover or risk taker. Finally, it can also be shown that an individual who has a linear Bernoulli utility function is risk neutral. This is because this function is equal to the expected utility function as a result of its linearity. That is, both utility functions coincide. The economic meaning of this case is that the individual is indifferent between obtaining \( \pi^* = 28 \) with certainty or uncertainty because in both cases she/he obtains the same level of Bernoulli utility and expected utility.

In summary, a risk averse individual has a concave Bernoulli utility function; a risk lover has a convex Bernoulli utility function; and a risk neutral has a linear Bernoulli utility function. This information has been used to develop an indicator of risk aversion named the coefficient of absolute risk aversion denoted by \( r_a \). In simple words, this indicator measures the degree of concavity of the Bernoulli utility function. This is captured using the following formula: \( r_a = - \frac{U''(\pi)}{U'(\pi)} \), where \( U'(\pi) \) and \( U''(\pi) \) denote the first and second derivatives of the Bernoulli utility function, respectively (Bar-Shira et al., 1997). When \( r_a \) is positive, the individual has a concave Bernoulli utility function meaning that this individual is risk averse (see Figure 3.3(a)). When \( r_a \) is negative, the individual has a convex Bernoulli utility function meaning that this
individual is risk lover (see Figure 3.3(b)). Finally, when $r_a$ is equal to zero, the individual has a linear Bernoulli utility function meaning that this individual is risk neutral (see Figure 3.3(c)). A formal and detailed explanation of the meaning of this coefficient and how is derived is provided in Appendix D.

### 3.3.2.2 The Mean-Variance Analysis (EV)

Let us now turn the discussion to the alternative theoretical thought referred to as the Mean-Variance Analysis (EV). This thought considers the incentives of agents to form portfolios of assets in order to reduce non-systematic risk. This analysis has been extended and applied to study the optimal behavior of farmers under risk. In particular, the EV assumes that risk averse farmers maximise their expected utility by choosing an efficient combination of agricultural activities (or efficient farm plan), providing the maximum expected return or gross margin given a determined level of business risk measured as the variance of gross margin\(^4\) (Lien, 2002; and Hardaker et al., 1997). This is why this approach is referred to as EV: E stands for the expected gross margin of the portfolio of crops; and V for the variance of the gross margin of this portfolio.

In the context of agriculture, the EV approach reflects the realistic situation faced by farmers who establish a number of crops at present with the objective of obtaining a future gross margin after harvesting the production. This temporal delay between sowing and harvesting has important implications in terms of farmers’ strategic cropping decision because they have to make expectations about the future gross margin that they will obtain after harvesting. A common strategy used to introduce expectations in this context is to assume that farmers consider the average of historical levels of gross margin.\(^4\) For a formal definition of business risk, see Footnote 1 in Chapter One. Footnote 2, on the other hand, explains why the variance (or standard deviation) of gross margin has been used as an indicator of business risk.
margin obtained in the past as an estimator of future gross margin. That is, they are assumed to have adaptive expectations (Dougherty, 2007). However, this estimator is not perfect because the level of gross margin is not constant and, consequently, it is difficult to predict with certainty future levels of gross margin from this indicator. The reason is because the level of gross margin is affected by a number of factors that cannot be predicted. As explained in Footnote 1 in Chapter One, this uncertainty in gross margin is referred to as business risk and is defined as the aggregate effect of all the uncertainty influencing the levels of gross margin made by a firm. This comprises production risk arising from weather uncertainty, market uncertainty arising from the unpredictable nature of output prices, institutional risk arising from unpredictable changes of rules affecting production, and personal risk arising from unpredictable events such as illness. As explained in Footnote 2 in Chapter Two, a common indicator used to represent business risk is the variance of the gross margin because this captures changes in gross margin that have been caused by these sources of uncertainty. The essence of the EV analysis is that it assumes that farmers maximise the expected gross margin of the portfolio of crops (i.e. the average of historical gross margin obtained in the past as a predictor of future gross margin) and minimises the associated business risk (i.e. the variance of gross margin) simultaneously by forming a convenient portfolio of crops. In other words, this individual maximises an expected utility $E(U(\pi))$ which depends positively on the level of expected gross margin of the portfolio of crops and negatively on the variance of this gross margin (a concrete functional form of this function is provided in subsection 3.3.2.3). In order to show how this maximisation problem is carried out, the concept of Efficient Frontier ($EF$) needs to be introduced. This concept is explained as follows.
The EF is defined as the line that joins the points of maximum expected gross margin for each level of risk that a portfolio of crops can offer when changing its mix of crops. The traditional theory establishes that a farmer maximises his/her expected utility \( E(U(\pi)) \) (i.e. maximises the expected gross margin of the portfolio and minimises the associated variance simultaneously) by choosing a particular portfolio of crops that is consistent with his/her attitude towards risk and preferences. In other words, farmers choose a single point on the EF. The latter is determined by the tangential point between the farmer’s indifference curve and the EF in the \( E(\pi) \)-\( V(\pi) \) geometric space, where \( \pi \) denotes gross margin; \( E(\pi) \) is the expected gross margin; and \( V(\pi) \) is the variance of the gross margin as a measurement of business risk. This optimal decision is shown in Figure 3.5.

Figure 3.5. The Mean-Variance Analysis.

In this figure a farmer maximises his/her expected utility at point \( a \). At this point, the EF and the indifference curve \( E(U(\pi))_0 \) are at a tangent and define a portfolio of crops that provides the maximum gross margin attainable \( E(\pi)_0 \) given the level of risk \( V(\pi)_0 \).
In order to gain a better understanding of the concepts discussed in this section, an example of how the expected gross margin of the portfolio, the variance of the gross margin of the portfolio, and the $EF$ are calculated is presented in Appendix E. This example also shows how individuals maximise their expected utility within the context of the Mean-Variance Analysis.

### 3.3.2.3 Differences between the SEU and the EV

The SEU and the EV have in common that both approaches describe how individuals make decisions under uncertainty. However, they differ in the type of decision under consideration. The SEU is normally used to study decisions that involve expectations about possible outcomes or states of nature that have some probability of occurrence. In particular, the SEU has been used to study individuals’ incentives to adopt insurance policies. An example is the Farmers & Mercantile Insurance Brokers who offers, among others, an Arable Farm Insurance that pays the full cost of hiring and replacement machinery in the event of a tractor, combine, machinery or drier fire\(^5\). The EV, in contrast, has been used to study individuals’ incentives to diversify their activities in order to reduce business risk. In the case of agriculture, the EV has been adopted to study farmers’ incentives to form portfolio of crops. This distinction between the SEU and the EV involves important differences that are described as follows:

a) **Expected gross margin**

\(^5\) Information about this company is found at [http://www.fandmgroup.co.uk/](http://www.fandmgroup.co.uk/)
The concept of expected gross margin used by the SEU is defined as a weighted average of the levels of gross margin that can be obtained in different states of nature, where the weights correspond to the probabilities of occurrence of these states. This concept is useful to study farmers’ incentives to adopt an insurance policy because the expected utility can be compared with the Bernoulli Utility in order to identify a level of gross margin that a farmer is willing to pay (i.e. the insurance premium). As an example, consider Figure 3.6.

![Figure 3.6: Incentive of a farmer to adopt an insurance policy.](image)

This figure presents the same case shown in Figure 3.4(a). That is, this figure shows the case of a risk averse farmer (i.e. a farmer who has a concave Bernoulli utility function) who faces two states of nature with positive probability: (i) the unfavorable state of nature associated with the low level of gross margin $\pi_L$ (in the Arable Farm Insurance
described above, this would be the event of a tractor, combine, machinery or drier fire); and (ii) the favorable state of nature associated with the high or upper gross margin $\pi_U$ (the event in which fire is not verified). The expected gross margin that the farmer obtains in this example is $\pi^*$. The expected utility that this farmer obtains from this level of gross margin is equal to $E(U(\pi^*))$. If this gross margin were obtained with certainty, then the farmer would obtain a utility equal to $U(\pi^*)$. Now, because $U(\pi^*) > E(U(\pi^*))$, the farmer has an incentive to pay a determined amount in order cover him/herself from the unfavorable state of nature. The maximum amount that this farmer is willing to pay in order to eliminate the risk of being in the unfavorable state of nature is $\pi^* - \pi^{**}$. This is because in case of the unfavorable state of nature was verified, the farmer would obtain at least his/her expected utility $E(U(\pi^*))$ with certainty (see Figure 3.6). The amount $\pi^* - \pi^{**}$ is actually the risk premium charged by the insurance company. Therefore, if the unfavorable event was verified, then the farmer would obtain a gross margin equal to $\pi_L$, plus the amount $\pi^* - \pi_L$ paid the company to compensate for the loss, minus the premium $\pi^* - \pi^{**}$ paid by the farmer for the insurance service. That is, in the unfavorable state of nature the farmer would obtain $\pi_L + (\pi^* - \pi_L) - (\pi^* - \pi^{**}) = \pi^{**}$ which is the same expected gross margin obtained after the farmer adopts the insurance policy: $\pi^* - \text{risk premium} = \pi^* - (\pi^* - \pi^{**}) = \pi^{**}$.

On the other hand, the expected gross margin considered by the EV analysis is defined as the average (or weighted average in more elaborated definitions as pointed out in Footnote 18 in Appendix E) of historical information of past gross margin. As explained in Section 3.3.2.2, it is assumed that farmers use this indicator as a predictor of the future gross margin of the portfolio of crops in order to determine the mix of crops that they will establish in the current year.
In order to see the difference between the expected gross margin defined by the SEU and the EV in mathematical terms, let us consider the following definitions. Let \( \pi_L \) be the gross margin that can be obtained in a particular state of nature with probability of occurrence \( \theta \), and let \( \pi_U \) be the gross margin that can be obtained in another state of nature with probability of occurrence \( 1 - \theta \). Let \( \pi_{t-i} \) the gross margin obtained in period \( t - i \), where \( t \) is the current period of time, and let \( \delta_{t-i} \) be the weight assigned to this level of gross margin in the weighted average considered by the EV analysis. Using these definitions, the expected gross margin considered by the SEU, \( E(\pi)_{SEU} \), and the expected gross margin considered by the EV, \( E(\pi)_{EV} \), are defined as:

\[
(i) \ E(\pi)_{SEU} = \theta \pi_L + (1 - \theta) \pi_U \\
(ii) \ E(\pi)_{EV} = \sum_{t-i} \delta_{t-i} \pi_{t-i}
\]

As shown in these equations, the concepts of expected gross considered by the SEU and the EV are different and represent different paradigms. Consequently, they have to be contextualised when referring to this indicator. As explained below, this thesis uses the concept of expected gross margin considered by the EV (i.e. Equation \( ii \)).

b) Expected Utility and Attitudes toward Risk

The expected utility considered by the SEU and the EV are also different. The SEU in particular defines expected utility as a weighted average of the Bernoulli utility evaluated at the gross margin obtained in the possible states of nature weighted by the probability of occurrence of these states. In contrast, the EV defines the expected utility as a function that depends on the expected gross margin defined under the EV and the
variance of the gross margin. Let $U(\pi_L)$ and $U(\pi_U)$ be the levels of utility reported by the Bernoulli utility function in the states of nature with $\pi_L$ and $\pi_U$, respectively, and let $\theta$ and $(1 - \theta)$ the respective probabilities of occurrence of these states. Let $r_a$ be the coefficient of absolute risk aversion defined in subsection 3.3.2.1 and Appendix D, and let $V(\pi)$ be the variance of the gross margin calculated using the same method than that adopted in the example presented in Table E.1 (see Appendix E). Using these definitions, the expected utility considered by the SEU, $E(U(\pi))_{SEU}$, and the expected utility considered by the EV, $E(U(\pi))_{EV}$, are defined as (the way in which $E(U(\pi))_{EV}$ is derived is explained in Appendix F):

(iii) $E(U(\pi))_{SEU} = \theta*U(\pi_L) + (1 - \theta)*U(\pi_U)$

(iv) $E(U(\pi))_{EV} = E(\pi)_{EV} - r_a*V(\pi)/2$

As explained above, the $E(U(\pi))_{SEU}$ represents the case of an individual who makes expectations about the level of utility that he/she will reach by considering the probabilities of occurrence of the possible outcomes of states of nature. In contrast, the $E(U(\pi))_{EV}$ represents the case of an individual who cares about maximising the expected gross margin defined under the EV and minimising the variance (i.e. minimising business risk) simultaneously.

Both formulations, however, have incorporated the coefficient of absolute risk aversion. This coefficient is implicitly incorporated in the $E(U(\pi))_{SEU}$ because this equation contains the Bernoulli utility function $U(\pi)$ (see equation iii), and the concavity of this function is what determines individuals’ attitudes toward risk and, therefore, the coefficient of absolute risk aversion (this idea is formally developed in Section 3.3.2.1
and Appendix D). On the other hand, the coefficient of absolute risk aversion is explicitly presented in the $E(U(\pi))_{EV}$ (see Equation iv). Note that when this coefficient is equal to zero, equation iv converges to $E(U(\pi))_{EV} = E(\pi)_{EV}$. This means that when the individual is risk neutral, minimising the variance is not an objective for this individual. This is consistent with the definition of risk neutrality. In contrast, when the coefficient of absolute risk aversion is very large, then minimising the variance becomes an important objective for a risk neutral individual. This is consistent with the behaviour of a risk averse individual who cares about minimising business risk. Finally, when the coefficient of absolute risk averse is negative (i.e. the case of a risk lover individual), maximising the variance rather than minimising the variance becomes a relevant objective for this individual. That is, this is the case representing a risk lover individual who prefers facing business risk.

Because the coefficient of absolute risk aversion is explicitly presented in the $E(U(\pi))_{EV}$, this function has been utilised as the objective function in mathematical optimisation models assuming the existence of a representative expected-utility maximiser within the EV approach. A model of this nature is shown as follows:

$$\text{Max } E(U(\pi)) = E(\pi) - r_a V(\pi)/2$$

Subject to

$$TB(\alpha_1, \alpha_2, \ldots, \alpha_n)$$
This model is very similar to that presented in expression 3.1 for the case of gross margin maximisation. The only difference is given by the objective function: gross margin maximisation considers only gross margin as the relevant target variable. In contrast, the utilitarian approach considers both gross margin and business risk as the relevant target variables. In other words, these models are identical only when business risk is not relevant for farmers. That is, when the coefficient of absolute risk aversion is equal to zero (i.e. \( r_a = 0 \)) which is only a particular case from a utilitarian point of view.

In fact, in order to calibrate the model, investigators calculate the coefficient of absolute risk aversion that minimises the difference between the current plan and that predicted by the model (see, for instance, Lien, 2002; and Wiens, 1976). This single coefficient of absolute risk aversion is then assumed to represent the attitude towards risk of all farmers. In addition, farmers are assumed to face the same technological constraints. In other words, this model considers the behaviour of the representative farmer.

It is important to highlight the fact that the concepts of variance of gross margin considered by the SEU and the EV are different and represent different paradigms. Consequently, they have to be contextualised when referring to this indicator. As explained below, this thesis uses the concept of variance of gross margin considered by the EV (i.e. Equation iv).

Finally, note that even when the SEU and the EV have been developed to explain different aspects of individuals’ decision making under uncertainty, they are related. This relationship is formally explained in Appendix F.

3.3.3 The utilitarian approach and the ESBF from the EV point of view
The EV branch of the utilitarian approach also offers an alternative explanation for the cropping choice made by the ESBF in response to the closure of the ASBF because this theoretical development was introduced with the purpose of explaining farmers’ decisions on forming portfolio of crops. This is why the EV was adopted in this thesis.

This can be seen from the following analysis. Sugar beet used to be a fairly safe crop because the price received by the beet growers was defined by the Sugar Beet Factory before these farmers established this crop. This is because factories were required to offer the minimum prices (i.e. the subsidised prices paid to farmers) in their annual contract with farmers in order to ensure a minimum return for them (Harris et al., 1983).

It is for this reason that farmers were able to reduce business risk by introducing sugar beet into their portfolios of crops. The implementation of the SRR, therefore, increased the risk of these portfolios because sugar beet was no longer an available choice after the closure of the ASBF. As a consequence, if the ESBF were risk averse (i.e. if they were expected-utility maximisers from the EV point of view), then it would be expected to find that these individuals replaced sugar beet with crops having low degree of business risk in order to maintain the low levels of risk of their portfolios. This is indeed a possibility because oilseed rape, wheat and barley (i.e. the crops that apparently were used by the ESBF to replace sugar beet as suggested by Clothier, 2010; and Department for Environment Food and Rural Affairs, 2010a) have lower levels of business risk (measured as the standard deviation of gross margin. See Footnote 2 in Chapter Two) than other available crops. This is formally shown in Table 3.2:

<table>
<thead>
<tr>
<th>Crop</th>
<th>Gross Margin* (£/hectare)</th>
<th>Standard Deviation** (£/hectare)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberries</td>
<td>9,071</td>
<td>2,668</td>
</tr>
</tbody>
</table>

Table 3.2 Gross Margin and Standard Deviation for some Selected Crops
Raspberries 7,047 2,021
Carrots 6,869 2,127
Parsnips 5,347 384
Potatoes 1,925 289
Wheat 472 141
Oats 408 125
Barley 379 118
Oilseed Rape 294 119


It is important to highlight, nonetheless, that the utilitarian approach constitutes a plausible explanation for the cropping choice made by the ESBF provided that these farmers are risk averse. While there is no information regarding the risk preferences of these individuals, many empirical studies have shown that farmers in general behave as if they were risk averse (Di Falco and Chavas, 2006; Dubois and Vukina, 2004; Holt and Chavas, 2001; Bar-Shira et al., 1997; Pope and Just, 1991; and Dillon and Scandizzo, 1978).

3.4 The Multiple Goals Approach

Another extension of the gross margin maximisation paradigm that can be used to explain the cropping choice made by the ESBF is the multiple goals approach. According to this point of view, the utilitarian approach is incomplete because farmers do not only consider gross margin and business risk when making their optimum decisions, but also consider non-economic variables such as maintaining family tradition and these can also affect their behaviour (Kliebenstein et al., 1980). The first part of this section explains the rationale of this approach and its extensions. The second part of the section, shows how this approach can be used to explain the cropping choice made by the ESBF in response to the closure of the ASBF.
3.4.1 The Multiple Goals Approach and Extensions

The pioneer researcher in this area was Gasson (1973) who showed that some of the variables considered by farmers when making their decisions constitute goals (i.e. ends or states related to what the individual desires to be or what they wish to accomplish) and values (i.e. any aspect of a situation, object or event that has a preferential implication of being good or bad, right or wrong). The author, based on her empirical findings, identified four types of value orientations. They were (i) instrumental in which farmers view farming as a means of obtaining income; (ii) social in which farmers farm for interpersonal reasons; (iii) expressive in which farming is considered as a means of self-expression; and (iv) intrinsic in which farmers value farming as an activity in its own right. The seminal work of Gasson has been adopted by other researchers who have found evidence supporting the hypothesis that non-economic goals and values also explain farmers’ behaviour (Kliebenstein et al., 1980; and Smith and Capstick, 1976). It has also found that the types of goals considered by farmers depend on specific characteristics such as age, education level and size of the farm, among others (Solano, et al., 2001; and Gasson, 1973). Consequently, value orientation is a function of a range of demographic and other situational variables.

The multiple goals approach has been extended with the objective of producing more elaborated optimisation models referred to as multiple goals models (Wallace and Moss, 2002; Hayashi, 2000; and Patrick and Blake, 1981). These models assume that the objective function of farmers is to minimise deviations from their target goals. A simplified version of the model proposed by Hazell and Norton (1986) is shown as follows:
\[ \text{Min } G = w_1(G_i - G_i^*) + w_2(G_j - G_j^*) + w_3(G_k - G_k^*) \]

Subject to \( (3.3) \)

\[ TB(\alpha_1, \alpha_2, ..., \alpha_n) \]

where \( G_i \) represent goal \( i \); \( G_i^* \) is the target that the farmer has for goal \( G_i \); \( (G_i - G_i^*) \) is the deviation from \( G_i^* \); and \( w_i \) is the weight that the farmer puts in this goal. In this model a farmer could not reach the targeted gross margin because this individual could have conflicting goals (i.e. decreasing one goal deviation can only be achieved by increasing the deviation of another goal from its target).

It is important to highlight the fact that this extension provides a more realistic description of farmers’ strategic behaviour than the utilitarian approach. Nonetheless, multiple goals models have important disadvantages that have been identified by different researchers. Firstly, Patrick and Blake (1981) argued that these models can be biased because the selection of goals and their importance are both arbitrary. That is, the selection of goals must be defined by the analyst. Secondly, researchers adjust the weights \( w_i \) in expression 3.5 until the model predicts outcomes that are consistent with reality. However, this adjustment does not have an easy interpretation. This has been formally pointed out by Hayashi (2000): “the correspondence between the actual results and the results obtained from the data input into the model does not mean the validity of the model (p. 496)”. As a consequence of the problem of weighting, it has been found that multiple objective models do not exhibit superiority over gross margin maximisation (Barnett, et al. 1982). Thirdly, multiple goals models assume an ad hoc set of technological restrictions. However, they omit other restrictions such as market
barriers or differences of land quality across farmers. Finally, multiple goals models rely on the representative agent assumption. That is, they assume that the behaviour described in the programming model represents the behaviour of a representative farmer. Nonetheless, it is not clear whether this assumption is satisfactory. This is because farmers could have differences in goals and the weight or significance that they attach to them; differences in technological restrictions and land quality; and differences in market restrictions.

3.4.2 The Multiple Goals Approach and the ESBF

Even though the multiple goals approach has been used mainly to study farmers’ strategic behaviour related to environmental problems, (Robinson et al., 2003; Costa and Rehman, 1999; Perkin and Rehman, 1994; Robinson, 1983; Ilbery, 1983; and Cary and Holmes, 1982), it can also provide a potential explanation of the crop allocations chosen by the ESBF. In order to understand this, it is useful to note that non-economic targets such as “enjoy my work” and “quality of life” have been found to be important farmers’ goals in some studies (Bergevoet et al., 2004; and Willock et al., 1999). If the ESBF considered these non-economic goals, then it is possible that they were unwilling to diversify into crops with high levels of gross margin after the closure of the ASBF because these crops were perceived to be very time consuming and, therefore, adopting them could prevent these farmers from achieving their non-economic goals.

3.5 The Theory of Planned Behaviour

Researchers have also considered social psychological theories to identify the underlying determinants of farmers’ conservation-related behaviour (see, for instance,
Zubair and Garforth, 2006; Burton, 2004; Beedell and Rehman, 1996; and Carr and Tait, 1991). Research in this area has considered in particular the theory of planned behaviour proposed by Ajzen (1985, 1991) to explain farmers’ behaviour. The objectives of this section are to describe this theory and to show how it can be used to explain the cropping choice made by the ESBF in response to the closure of the ASBF.

3.5.1 Rationale underlying the Theory of Planned Behaviour

This theory establishes that intention is a good predictor of behaviour, and that intention is determined by attitudes, subjective norms and perceived behavioural control. Figure 3.7 shows a graphical representation of this theory.

![Figure 3.7 Theory of Planned Behaviour (Adapted from Burton, 2004)]

Ajzen (1991) explained that each of the three components is associated with a specific belief. Attitudes towards different behaviours, in particular, are determined by behavioural beliefs. In relation to this point, Ajzen (1991) argued that individuals form beliefs about an object by associating it with certain attributes, with other objects, characteristics, or events, and each belief links the behaviour to a certain outcome, or to some other attribute such as the cost incurred by performing the behaviour. Because the attributes linked with behaviour are already valued positively or negatively, individuals
automatically and simultaneously acquire an attitude toward the behaviour. This idea is summarized according to the following equation:

$$A \propto \sum_{i} b_{i} e_{i}$$  \hspace{1cm} (3.4)

Where $A$ is attitude, $b_{i} > 0$ is the strength of belief $i$, $e_{i}$ is the subjective evaluation of the belief’s attribute $i$, and the symbol $\propto$ denotes “proportional to”. As an example, consider the attitude of an individual toward the activity of going to the beach. There are two associated belief attributes: developing skin cancer ($e_{1}$), and meeting people of the opposite sex ($e_{2}$). Let us assume for simplicity that $A = b_{1} e_{1} + b_{2} e_{2}$. Because $e_{1}$ can be considered as a negative attribute (i.e. $e_{1} < 0$) and $e_{2}$ a positive attribute (i.e. $e_{2} > 0$), if $b_{2} e_{2} > -b_{1} e_{1}$, given the strength of each attribute, then $A > 0$ for which this person has a positive attitude toward the behaviour of going to the beach.

Subjective norms, on the other hand, are assumed to be associated with normative beliefs. In relation to this point, Ajzen (1991) explained: “Normative beliefs are concerned with the likelihood that important referent individuals or groups approve or disapprove of performing a given behaviour (p. 195)”. This idea is represented in the following equation:

$$SN \propto \sum_{i} n_{i} m_{i}$$  \hspace{1cm} (3.5)

Where $SN$ denote subjective norm; $n_{i} > 0$ is the strength of normative belief $i$; and $m_{i}$ is the person’s motivation to comply with the related referent. Consider again the example

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6 This example was adapted from Ajzen (1991), p. 194.
of the beach, and suppose that there are two referent groups: parents ($m_1$) and friends ($m_2$). If parents disapprove of the activity of going to the beach, then $m_1 < 0$. On the contrary, if friends approve this behaviour, then $m_2 > 0$. Let us assume that $SN = n_1m_1 + n_2m_2$. If $n_2m_2 < - n_1m_1$, then $SN < 0$ meaning that this individual will have a negative subjective norm toward going to the beach.

Finally, regarding the perceived control component of the theory of planned behaviour, it is assumed to be linked with control beliefs. In relation to this point, Ajzen (1991) explains that control beliefs are the beliefs that individuals have in terms of their resources and opportunities they possess, and the fewer number of obstacles or impediments they anticipate. If an individual believe that he/she has resources and opportunity to succeed when performing a particular behaviour, then the greater should be her/his perceived control over the behaviour. This idea is summarised in the following expression:

$$PBC \propto \sum_{i} c_i p_i \quad (3.6)$$

Where $PBC$ denote the perception of behavioural control; $c_i > 0$ is the control belief of factor $i$; and $p_i$ is the perceived power of the particular control factor to facilitate or inhibit performance of the behaviour. To understand this concept, consider the example of the beach. Assume that the individual has two control beliefs: the belief that he/she is attractive for the opposite sex ($c_1$), and that protective cream is not good to prevent skin cancer ($c_2$). Let us assume for simplicity that $PBC = c_1p_1 + c_2p_2$. Because $c_1$ can be considered as a positive control belief (i.e. $c_1 > 0$) and $c_2$ a negative control belief (i.e. $c_2$
< 0), if \( c_1p_1 > c_2p_2 \), given the strength of each control belief, then \( PBC > 0 \) for which this person will have an incentive to visit the beach.

The theory of planned behaviour assumes that the behavioural intention toward a particular behaviour is the result of these three forces as illustrated in the following function:

\[
BI = w_A A + w_{SN} SN + w_{PBC} PBC
\]  

Where \( BI \) is the behavioural intention toward a particular behaviour (in the example \( BI \) corresponds to the behavioural intention towards going to the beach); and \( w_A, w_{SN}, \) and \( w_{PBC} \) are the weighting that the person attaches to the behavioural beliefs (\( A \)), normative beliefs (\( SN \)), and control beliefs (\( PBC \)), respectively.

In summary, the theory of planned behaviour argues that a person will have an intention (motivation) to behave in a particular way when she/he has an attitude toward this behaviour (positive attitude), when the people who are important to him/her think that he/she should perform this behaviour (positive subjective norms), and when the person has the conviction that she/he will successfully execute a behaviour leading to a particular outcome (positive behavioural control).

3.5.2 The Theory of Planned Behaviour and the ESBF

The theory of planned behaviour can also offers an alternative explanation for the cropping choice made by the ESBF at the individual level. This is because it can be
used to link intention toward adopting new crops with attitudes, subjective norms and perceived behavioural control. In fact, there are many ways in which this theory can explain these allocations. In order to illustrate this, some particular examples are provided as follows. Considering the attitude component of the theory (see Figure 3.7), a farmer who has a positive attitude towards family life and family tradition (i.e. a farmer who believes that maintaining family life and farming tradition is important) could eventually be prevented from selecting time consuming crops with high levels of gross margin. This is because this farmer would face a trade-off between devoting his scarce time to his family and to the productive process of these crops.

In considering the subjective norm component of the theory, on the other hand, it is possible that subjective norms in agriculture also influence cropping decisions. For example, a farmer could be prevented from choosing a particular crop when considering neighbours’ opinions regarding the expected gross margin of this crop. That is, if neighbours had not adopted this crop because they had a bad opinion about it, and if the farmer believes that the opinion of these neighbours is important, then he could decide not to produce this crop. Finally, to see how the perceived behavioural control component of the theory could affect farmers’ cropping decision, consider the case of a farmer who believes that he/she does not have the necessary resources and opportunities to produce crops with high levels of gross margin. According to the theory, this farmer will probably be prevented from producing these crops because she/he has the belief that he/she does not have control over the resources needed to successfully carry out these activities.

3.6 Market and Material Resources Barriers Approach
The existence of market and material resources (i.e. capital, technology and land quality) barriers can also explain the cropping choice made by the ESBF. Regarding market barriers, it is recognised that the vertical relationship between suppliers and retailers of fresh produce in the UK is dominated by nine large retailers, Tesco being the largest of these (Duffy et al., 2003; and White, 2000). This asymmetry is explained by the high concentration of market power exercised by these retailers and by strategic innovations adopted by them (Burt and Sparks, 2003; and Collins and Burt, 1999). According to Duffy et al. (2003), retailers establish high standards such as food safety, quality and volume assurance, and suppliers are the agents who deal directly with farmers in order to guarantee these required standards. It is possible that these requirements and the exclusivity of participating in this supply chain with power imbalance have limited the ESBF from adopting crops with high levels of gross margin such as parsnips and carrots (i.e. they constitute entry barriers to the industry of fresh produce). Apparently this problem is not presented in the supply chain for traditional crops as this chain is more diversified in terms of the number of intermediaries and retailers involved in it. This is formally shown in Figures 3.10 and 3.11 for two common traditional crops in the West Midlands.
Figure 3.8 Supply chain of wheat. Source: Frontier Economics (2005).
Given the higher diversity of intermediaries and retailers that are present in the supply chain for traditional crops, it is probably more difficult to sustain power imbalance in the relationship between suppliers and retailers. This suggests that farmers do not face significant entry barriers in these industries. This can explain why the ESBF chose traditional crops to replace sugar beet in response to the closure of the ASBF.
There are other restrictions that can limit farmers’ cropping choices such as crop rotation requirements\(^7\), irrigation, capital restrictions, technological limitations, and differences in land quality, among others. They correspond to material resources restrictions and, as such, they can limit farmers’ ability to develop adaptive capabilities (see the dynamic capabilities approach discussed in Sections 3.2.2 and 3.2.3). For example, a farmer who works poor quality land (i.e. Land Grades 3, 4 and 5) cannot produce horticultural crops and this, in turn, limits farmers’ opportunity to adapt in turbulent conditions. Since 48% of the arable land in the West Midlands is Land Grade 3 and is located in the counties of Shropshire and Staffordshire (See Table A2 in Appendix A), it is not surprising that a large percentage of the ESBF have chosen cereals and crops with low gross margin in response to the closure of the ASBF. In summary, the existence of these barriers, and in special land quality, is a critical feature in agriculture because they reduce strategic choice. Understanding the way in which farmers respond when these barriers are presented is one of the aims of the current research. It is for this reason that market and material resources barriers have been considered as one of the key components of the holistic multivariate model that is proposed in this thesis.

3.7 Institutional Theory

The approaches of individual behaviour reviewed in the previous sections can address the issue of why farmers have replaced sugar beet with crops with low gross margin. However, they cannot explain why different farmers have apparently chosen the same crops with low gross margin such oilseed rape, wheat and barley to replace sugar beet

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\(^7\)Crop rotation requirement is associated with the concept of break crop. According to Kirkegaard et al. (2008), a break crop “refers to breaking the life cycle of crop-specific pathogens by growing a non-host crop in sequence” (p. 187).
after the closure of the ASBF as suggested by Clothier (2010) and Department for Environment Food and Rural Affairs (2010a). This has indeed been confirmed by the dealer who used to work in the ASBF before the implementation of the SRR (personal communication with Mr David Allison). One approach that can explain this collective behaviour is referred to as Institutional Theory.

This theory is based on the concept of social construction which assumes that individuals perceive the world subjectively, and this perception is influenced by social norms, social prescriptions and collective beliefs. Thus, when individuals perceive the world in a particular way, they behave accordingly creating a world in line with their perceptions (Johnson and Greenwood, 2007). Collective beliefs, on the other hand, are transmitted from repeated interactions between individuals and organisations and become internalised, legitimised and reinforced by habit formation and regulatory processes (Hodgson, 2006; Soderbaum, 2000; and Bush, 1987). When collective beliefs and social prescriptions are legitimised and taken for granted, the system of established and prevalent social rules (i.e. norms of behaviour, social conventions and legal rules) have the power to structure social interactions. In this case this system is referred to as an institution (Hodgson, 2006) and is supported and stabilised by power relationships and social controls (Lawrence et al., 2001).

There are two concepts used in the institutional theory that explain why farmers in the West Midlands have in general specialised in the same few crops, and why the ESBF in particular have chosen the same crops to replace sugar beet. They correspond to isomorphism and mimicry. Isomorphism is the process by which similar and stable organisations in a population adopt similar practices (Greenwood and Hinings, 1996). Organisational forms converge isomorphically because behaviours are patterned and
reproduced when social norms become taken for granted (Greenwood and Suddaby, 2006; and DiMaggio and Powell, 1983). Since homogeneous firms having similar social expectations (i.e. they share the same social prescriptions) are likely to interpret ideas in the same way, they adopt similar strategies and managerial arrangements. As a result, strategic choice is directed and constrained by institutional prescriptions (Johnson and Greenwood, 2007). Given the fact that farmers in the UK operate mainly on a family basis and they exist in a farming community (Lobley, 2010) they could be considered as relatively homogeneous organisations. If this were true, then isomorphism could potentially explain why these organisations adopted the same strategy (same crops to replace sugar beet) after the closure of the ASBF. Mimicry, on the other hand, is a mechanism by which firms copy organisations that are perceived to be both more legitimate and successful. This occurs in situations of uncertainty and ambiguity (Johnson and Greenwood, 2007; and Haunschild and Miner, 1997). Because the implementation of the SRR increased ambiguity and uncertainty in the business environment, it is possible that the ESBF copied the crop options adopted by farmers who were perceived as legitimate and successful organisations. This leads us to expect a high level of homogeneity in decision making about cropping choices and farmers’ strategic behaviour.

The institutional theory offers a useful theoretical argument to explain the cropping choice made by the ESBF. However, it is important to emphasise the fact that these farmers could also have had very limited alternatives to replace sugar beet in response to the closure of the ASBF. From this point of view, it is perhaps not surprising that all the ESBF made similar (although not identical) choices.
3.8 Relationship between the Approaches

It is important to highlight the fact that the approaches considered in this chapter are not completely independent. That is, there exist important overlaps among them. These overlaps are presented in Figure 3.10.

Figure 3.10: Overlaps among the Approaches Considered in the Chapter
According to this figure, the utilitarian approach is included in the multiple goals approach. This is because the utilitarian approach argues that farmers are concerned about maximising gross margin and minimising business risk simultaneously. But these objectives correspond to farmers’ goals. The multiple goals approach and the utilitarian approach also overlap the dynamic capabilities approach. To see why, note that the objective of minimising business risk depends on farmers’ attitudes toward risk. But this latter is a determinant of dynamic capabilities because this affects farmers’ incentives to innovate (Delmas, 2002). The dynamic capabilities approach also overlaps the theory of planned behaviour. This is because the latter involves farmers’ attitudes toward behaviour. Therefore, if the behaviour is, for example, to adopt new relevant information, and if a farmer has a negative attitude towards this behaviour, then this individual will not adopt new information. But this lack of interest is also captured by the dynamic capability approach as lack of self-motivation in terms adopting new information (Cohen and Levinthal, 1990). For example, external information about an alternative market opportunity could help farmers to create competitive advantage by diversifying their production in order to reach this market. However, if a farmer had a negative attitude towards this external information (for example, as a consequence of past bad experiences), then he/she could be prevented from using it. That is, this attitude could negatively affect farmer’s self-motivation in terms of taking advantage of this information. The market and resource barriers approach, on the other hand, belongs to the dynamic capabilities approach. For example, lack of capital can affect farmers’ opportunity to innovate and to adjust in dynamic environments (Chakravarthy, 1982; and Gibson and Birkinshaw, 2004). Finally, the institutional theory overlaps the multiple goals approach and the theory of planned behaviour because collective beliefs and existing social norms can affect farmers’ goals as well as their attitudes and perceived behavioural control (Hodgson, 2006; and Soderbaum, 2000). For example, if
the idea that environmental damage is an important issue becomes legitimised and reinforced, then farmers will probably include the goal of maintaining nature and environmental values into their set of goals. They will also have a positive attitude towards using environmental practices when producing their crops. Note, on the other hand, that because the dynamic capabilities approach overlaps the theory of planned behaviour and the multiple goals approach, it is inferred that the institutional theory also overlaps the dynamic capabilities approach. For example, norms and social rules can affect farmers’ attitudes toward risk. But this also affects farmers’ capacity to develop dynamic capabilities via innovation.

The overlaps described in this section have been considered in the multivariate framework proposed in this thesis. This framework is formally presented in the introduction of the next chapter.

3.9 Chapter Summary

The present chapter has reviewed alternative approaches that might offer an answer to the two main questions related to the strategic decision made by the ESBF in response to the closure of the ASBF, namely: why did these farmers replace sugar beet with crops having low gross margin in response to this closure?; and why did these individuals choose the same crops to replace sugar beet? Five alternative and complementary approaches of individual behaviour were identified as potential candidates to answer the first question. They correspond to (i) dynamic capabilities; (ii) the utilitarian approach; (iii) the multiple goals approach; (iv) the theory of planned behaviour; and (v) the market and material resources barriers approach. As well as these individual
approaches, one approach of collective behaviour was identified as a potential candidate to answer the second question: institutional theory.

The dynamic capability approach argues that firms can successfully adjust in turbulent conditions by integrating, reconfiguring, renewing and recreating resources in response to environmental change in order to reach and sustain competitive advantage. According to this approach, the low gross margin choice made by the ESBF can reflect the fact that these farmers were unable to develop dynamic capabilities when the ASBF was closed. This, in turn, could indicate that key drivers of dynamic capabilities were not available for these individuals. For example, one important driver identified in the literature review is access to capital. A farmer who does not have this driver cannot invest in machinery that is needed to produce crops with high gross margin.

The utilitarian approach can also explain why the ESBF adopted crops with low gross margin in response to the closure of the ASBF. According to this approach, farmers not only care about maximising gross margin when choosing their productive plans, but also about minimising the associate business risk. In this case risk averse farmers would be willing to select crops with low gross margin with the purpose of reducing market risk. This is because these crops are normally associated with low levels of business risk.

The multiple goals approach postulates that farmers make their strategic decisions by considering goals that do not necessarily respond to economic considerations. For example, a farmer could be interested in producing traditional crops with low gross margin with the objective of maintaining the productive tradition of the family. This
suggests that the choice made by the ESBF could reflect their attempts to achieve non-economic goals.

According to the theory of planned behaviour, the realisation of a particular behaviour by an individual is influenced by three main factors: the individual’s attitudes towards this behaviour; the individual’s perception of the probability to success when performing the behaviour (i.e. perceived behavioural control); and how important is the opinion of his group of reference about performing this behaviour (i.e. subjective norms). This approach can also explain the choice made by the ESBF. For example, a farmer could have adopted a crop with low gross margin to replace sugar beet because he believed that producing crops with higher levels of gross margin required knowledge and skills that were difficult to obtain. The low gross margin choice could also indicate that these farmers were influenced by the opinion of neighbours who were not willing to be involved in alternative crops with higher levels of gross margin.

The market and material resources barriers approach argues that farmers can strongly be limited in their capacity to diversify into crops with high gross margin when they face market barriers such as power imbalance in the relationship between retailers and producers and resources barriers such as land quality. For example, a farmer who is faced with low land quality would be unable to adopt a crop with high gross margin that requires excellent land conditions.

Finally, the institutional theory argues that individuals adopt similar strategies when their beliefs converge, are taken by granted and are reinforced by formal and informal rules such as formal laws and social repression. This can explain why the ESBF chose the same crops to replace sugar beet in response to the ASBF.
All the approaches of individual behaviour not only complement each other but also overlap to some extent. Consequently, they can be synthesised into a more holistic framework which can provide more realistic predictions. To see why this integration can offer a better description of farmers’ strategic behaviour, consider again the example of the sugar beet farmer given in the introduction of this chapter. In this example, it was assumed that this farmer is faced by constraints of land quality, access to capital and lack of knowledge of crops with high levels of gross margin. These restrictions could limit the cropping choices of this farmer because land quality, knowledge and capital are important drivers of dynamic capabilities. In other words, the existence of market and material resource restrictions would limit the ability of the farmer to reach competitive advantage in the turbulent condition caused by the closure of the ASBF. Moreover, the decision of selecting crops with low gross margin to replace sugar beet would be reinforced if this individual was also risk averse and if he considered non-economic goals such as maintaining the productive tradition of the family. Likewise, this decision would be reinforced if this individual had a negative attitude towards the production of crops with high gross margin, if he/she believed that he/she does not have the capacity to develop a successful business with these crops, and if this farmer was strongly influenced by the opinion of neighbours who are not involved in the production of crops with high levels of gross margin. This example suggests that a fully description of farmers’ strategic decisions requires the identification of a number of factors that interact simultaneously. This is why the integration of the approaches of individual behaviour offers the opportunity to consider a number of potential factors from complementary sources that can contribute in the development of a more realistic description of farmers’ strategic behaviour.
It is important to stress the fact that the approaches of individual behaviour described above have been used as the basis for the holistic multivariate model of crop allocations proposed in this thesis. In contrast, the institutional theory has been used to infer patterns of collective behaviour from the proposed multivariate model. The integration of the approaches if individual behaviour considered in this chapter and the description of the patterns of collective behaviour inferred when adopting the institutional theory is the focus of the next chapter.
Chapter Four: THEORETICAL DEVELOPMENT: THE PROPOSED HOLISTIC MULTIVARIATE MODEL

4.1 Introduction

The market shock considered in this research (i.e. the closure of the ASBF) restricted the farming opportunities of the ESBF because sugar beet had been a crop with a relatively good level of gross margin and with minimal market risk and there were therefore no obvious comparable substitutes (market risk is formally defined in Footnote 1 in Chapter One). As the sugar beet factories were obliged to offer the subsidised prices to farmers before they decided whether to produce sugar beet, the farmers knew exactly what income that they would obtain from this crop. As a result, sugar beet was only affected by climatic risk, but not by the market risk generated by price volatility.

The closure of the ASBF meant that this crop was no longer an option for the ESBF because no alternative relevant market for this crop was available in the West Midlands. As a consequence, these farmers had to replace sugar beet with an alternative crop. The key point in this choice is that when the SRR was implemented, no perfect substitutes of sugar beet were available because no crop was free of market risk. Because farmers had no control over this problem, they had to accept the fact that they would only be able to select a future portfolio of crops with a higher level of business risk (for a formal definition of business risk, see Footnote 1 in Chapter One). In this context, the ESBF apparently replaced sugar beet with crops with low levels of gross margin in response to the closure of the ASBF (Clothier, 2010; and Department for Environment Food and Rural Affairs 2010a).
The issue at hand is the question of why farmers made this cropping choice. The review developed in Chapter Three offered a number of alternative approaches and points of view that might be able to offer answers to this question. Specifically it was found that these approaches were able to offer a clearer picture in addressing two questions associated with this strategic choice: the issue of why ESBF apparently chose crops with low gross margin to replace sugar beet after the closure of the ASBF; and the issue of why all these farmers apparently chose the same crops (oilseed rape, wheat and barley) to replace sugar beet.

Regarding the first question, five alternative and complementary approaches to individual behaviour were found to be of use in addressing this question: (i) dynamic capabilities; (ii) utilitarian approach; (iii) multiple goals approach; (iv) theory of planned behaviour; and (v) market and material resources barriers approach. All these approaches were considered to be useful in helping to gain a clearer picture of the factors influencing the farmers’ cropping choice. Regarding the second question, on the other hand, one approach of collective behaviour was found to be helpful in addressing the issue of why the ESBF chose the same crops in response to the implementation of the Sugar Regime reform (SRR): institutional theory.

Given that all these approaches were considered to be of use in addressing these central questions, it was decided that a more hybrid approach, which integrates aspects of these approaches into a unified model with more explanatory variables and predictive power, is needed to explain the farmers’ strategic behaviour. The objective of the current chapter is to develop such a framework by integrating all these approaches into a single multivariate model under the assumption that farmers’ strategic behaviour is explained.
by a multiplicity of economic and non-economic drivers considered by these approaches. A schematic representation of the approaches considered in the proposed model is presented in Figure 4.1.

![Figure 4.1: The Approaches Considered in the Proposed Multivariate Model for Crop Allocations](image)

According to this figure, a crop allocation chosen by an individual farmer (Box a) reflects a business strategic decision made by this agent (Box b). This decision, in turn, is influenced by farmer’s attitudes towards business risk (Box c); farmer’s goals (Box d); the ability of this individual to develop dynamic capabilities in turbulent conditions (Box e); the existence of market and material resources barriers (Box f); farmer’s attitudes toward farming, subjective norms and perceived behaviour (Box g); and by the
institutional theory via the theory of planned behaviour, the multiple goals approach and the utilitarian approach (Box h). Figure 4.1 also shows existing relationships between the approaches considered in this framework. This is because there are overlaps among these approaches which are formally described in Section 3.8.

The approaches considered in Figure 4.1 were used to identify specific variables that could potentially affect farmers’ cropping decisions. These variables were used as independent variables in the proposed multivariate model. The dependent variable considered in this model was the level of expected gross margin of the portfolio of crops chosen by the ESBF. This is because different levels of expected gross margin reflect different crop allocations. That is, two different portfolios of crops represent two different crop allocations and they are also linked to two different levels of expected margin, one for each portfolio. Consequently, the impact of independent variables on crop allocations can be investigated by considering the impact of these variables on the levels of expected gross margin achieved by the portfolio of crops chosen by the farmers. The proposed multivariate model is presented in the following figure:

![Figure 4.2 The Proposed Multivariate Model for Crop Allocations.](image-url)

<table>
<thead>
<tr>
<th>Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables considered by the approaches presented in Figure 4.1. (e.g. farmers’ attitudes toward risk; resources; farmers’ goals; stock of capital; differences of land quality, attitudes towards farming; etc).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Gross Margin of the Portfolio of Crops</td>
</tr>
</tbody>
</table>

8 Most of the independent variables included in this model correspond to statements that were adapted from related academic works. They are listed in the questionnaire presented in Appendix L.
This framework is an extension of the original work of Gasson (1973) and offers an alternative way of examining the issue of crop allocations when factors other than economic considerations affect farmers’ cropping decisions. In particular, the proposed model extends the work of Gasson (1973) by means of the introduction of other approaches that can also explain farmers’ strategic cropping decisions such as the theory of planned behaviour, institutional theory and the dynamic capabilities approach. This extension offers, therefore, a richer description of farmers’ cropping decisions. It is important to recognise that some researchers have already integrated the multiple goals approach and the theory of planned behaviour into a common framework referred to as multivariate model. However, the objective of these researchers was to study farmers’ willingness to adopt environmental practices but not to study decisions on crop allocations (see, for example, Rehman et al., 2007; Bergevoet et al., 2004; Willock et al., 1999; Austin et al. 1998a; and Austin et al. 1998b). This makes the proposed multivariate model an original contribution in the area of strategic decisions on crop allocation.

The advantage of the proposed multivariate model with respect to the seminal work of Gasson (1973) is that it includes the approaches that are presented in Figure 4.1 in a way in which heterogeneous behaviour across farmers can be identified graphically, a fact that is formally shown in the present chapter. This, in turn, permits the identification of behavioural patterns that can be used to cluster farmers according to their cropping strategy in turbulent business environment, and also to develop specific hypotheses.

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9Academic works based on this model have been developed by the author of this thesis. These works have been accepted to be published in the International Journal of Agricultural Management, the Aspects of Applied Biology, the International Journal of Economic Behaviour, the International Journal of Applied Behavioural Economics, the International Journal of Strategic Business Alliances, the Journal of Business and Economics, and in the peer reviewed proceedings of the Annual Conference of Economic Forum of Entrepreneurship & International Business. The abstracts of these articles are presented in Appendix G.
concerning farmers’ cropping decisions. This is, in fact, the main strength of the model and the main contribution of this thesis.

The chapter is structured as follows. Section 4.2 establishes a benchmark condition characterised by the existence of a representative farmer whose only concern is maximising an expected utilitarian function. Section 4.3 uses this benchmark condition for the purpose of determining how farmers’ behaviour deviates from this benchmark when the other approaches considered in the holistic multivariate model presented in Figure 4.2 are introduced. These behavioural deviations have been used to identify theoretical behavioural patterns across farmers and these patterns, in turn, have been used to propose a number of testable hypotheses on farmers’ strategic behaviour. These hypotheses constitute the research hypotheses defined for the current investigation. Section 4.4 proposes a typology to classify farmers according to their strategic behaviour inferred from the proposed holistic multivariate model. Finally, Section 4.5 summarises the chapter.

4.2 The Representative Farmer and the Benchmark Condition

4.2.1 Establishing the Benchmark Condition

The utilitarian approach constitutes a convenient benchmark condition to study farmers’ strategic behaviour because it provides a graphical representation that can be used to visually identify behavioural patterns across farmers. This representation is shown in Figure 4.3 below. Considering this advantage, this section develops a very simple version of this approach with the objective of establishing the benchmark condition used in the current research. In particular, it is assumed that farmers are completely
institutionalised. That is, it is assumed that they have converged isomorphically and they behave identically as a consequence of mimicry (see the review on institutional theory given in section 3.7). As a consequence, it is assumed that these individuals all have the same attitudes towards risk and they do not have goals others than maximising gross margin and minimising business risk. Under these assumptions, the existence of a representative farmer who maximises an expected utility function $E(U(\pi))$ by choosing a portfolio of crops achieving the maximum possible expected gross margin $E(\pi)$ per unit of business risk $V(\pi)$ can be inferred (an indicator of business risk used in this thesis is the variance of gross margin, $V(\pi)$. Footnote 2 in Chapter Two explains why this indicator is appropriate to represent business risk). This optimum behaviour is shown in Figure 4.3:

![Expected Gross Margin, E(\pi)](Expected Gross Margin, E(\pi))

![Variance of the Gross Margin, V(\pi)](Variance of the Gross Margin, V(\pi))

Figure 4.3 Benchmark Condition and the Representative Farmer.

According to this figure, the representative farmer maximises his/her expected utility at point $a$. At this point, the efficient frontier ($EF$) and the indifference curve given by $E(U(\pi))$ are at a tangent and define a portfolio of crops that provides the maximum
gross margin attainable \( E(\tau_0) \) given the level of business risk \( V(\tau_0) \) (an example of how the EF is generated is presented in Appendix E).

4.2.2 Implications of the Existence of a Representative Farmer

The main implication of the idea of the existence of a representative farmer is that all farmers are supposed to choose the same portfolio of crops consistent with point \( a \) in Figure 4.3 in the benchmark condition. In this context, the traditional utilitarian approach argues that deviations from point \( a \) are explained mainly by differences of attitudes towards risk across farmers (Halter and Beringer, 1960; Johnson, 1962; and Dillon and Scandizzo, 1978).

The next section shows that farmers with the same attitudes towards risk can also manifest heterogeneous behaviour when facing asymmetries in terms of non-economic drivers (i.e. when introducing the multiple goals approach and the theory of planned behaviour into the proposed multivariate model); when facing different market and material resources barriers; and when having different opportunities to develop dynamic capabilities in turbulent conditions. This theoretical finding not only challenges the traditional utilitarian approach, but also provides new opportunities to explore behavioural patterns of farmers having the same attitudes towards risk. This theoretical development is formally studied in next section.
4.3 Behavioural Patterns across Farmers: Introducing Asymmetries into the Benchmark Condition

Under the assumptions given in the previous section, it would be expected to find that all the ESBF chose a particular crop allocation consistent with point $a$ in Figure 4.3 in response to the closure of the ASBF. However, it is very unlikely that all these assumptions were verified when the SRR was implemented. For example, Table A.2 in Appendix A shows that land quality in the West Midlands region is heterogeneous and this constitutes a potential source of heterogeneous strategic behaviour. Differences of market and material resources barriers; farmers’ goals; farmers’ attitudes toward farming; farmers’ perceived behavioural control; subjective norms; and farmers’ ability to develop dynamic capabilities can also constitute potential sources of heterogeneous behaviour. As a consequence, the existence of these asymmetries could in theory generate important behavioural deviations from the benchmark condition defined in Figure 4.3. Capturing these deviations is the objective of this section.

The first part of this section analyses behavioural deviations from the benchmark condition when farmers face heterogeneous market and material resources barriers. This part shows, in particular, that a predictable optimal behavioural path can be inferred under some assumptions related to farmers’ attitudes toward risk. This result has been formalised in a novel theory that has been named the multiple efficient frontiers theory (MEFT). The second part analyses how farmers’ strategic behaviour deviates from the theoretical optimal path inferred from the MEFT when they consider different non-economic drivers when making their cropping decisions. That is, this part introduces the multiple goals approach and the theory of planned behaviour into the analysis. Finally, the last part analyses how behaviour deviates from the theoretical optimal path inferred
from the MEFT when allowing farmers to have the conditions needed to develop
dynamic capabilities.

4.3.1 Introducing Heterogeneous Market and Material Resources Barriers: the
Multiple Efficient Frontiers Theory

The representative farmer assumption is not a realistic approach when considering the
agricultural sector even with the assumption of similar attitudes towards risk (i.e. the
same value of the coefficient of absolute risk aversion in Equation F.2 in Appendix F).
In order to understand this, it is worth noting that the utilitarian approach was initially
developed with the objective of studying the incentives of investors to form portfolios
of financial assets. In this context, the existence of a representative financial investor
facing a single efficient frontier (EF) under the assumption of identical attitudes toward
risk is reasonable. This is due to the fact that investors obtain the same expected return
and level of risk for a particular financial asset. In other words, a particular asset does
not report different levels of expected return for different investors. In addition,
financial assets are normally available to all investors. In agriculture, by contrast, these
conditions do not hold for the following reasons. First, a particular crop does not
normally offer the same expected gross margin to different farmers. This is because
farmers face asymmetries such as differences in land quality, among others. Second, not
all crops are available to farmers because they normally face different restrictions such
as market barriers.

In synthesis, there are different channels by which farmers having the same attitudes
toward risk might not necessarily maximise utility at point $a$ in Figure 4.3. The
following analysis illustrates this more complex situation by extending the traditional
EV approach of the utilitarian approach (see Section 3.3.2.2) by introducing the following factors: differences in market and material resources barriers across farmers. This extension constitutes one of the main contributions of the present study and has been used to develop a novel theory to describe farmers’ cropping decisions that has been called in this thesis the *multiple efficient frontiers theory* (MEFT).

This theory has three main components. The first component is a descriptive one (i.e. the descriptive component of the MEFT) and postulates that farmers facing different market barriers or different resource restrictions such as land quality cannot face the same efficient frontiers (EFs), even when adopting the same crops. The second component is a behavioural one (i.e. the behavioural component of the MEFT) and postulates that farmers who have limited choices will always form portfolio of crops with efficient frontiers that allow them reach higher levels of expected gross margin and lower levels of business risk when maximising their expected utility (defined under the EV approach as described in Section 3.3.2.2). Finally, the last component is a consequential one (i.e. the consequential component of the MEFT) and postulates that when farmers face different market barriers or different resource restrictions and when they behave as described by the behavioural component of the theory, an optimal path consisting of a negative relationship between expected gross margin and business risk arises. This path represents different optimal crop allocations chosen by different farmers facing different market barriers or different resource restrictions. A formal mathematical development of this theory is presented in Appendix H.
4.3.1.1 The Descriptive Component of the MEFT

According to the MEFT, farmers do not necessarily face a single efficient frontier \((EF)\) as the traditional utilitarian approach postulates. Conversely, given the heterogeneous conditions faced by them, there is in reality one \(EF\) line for each farmer. For example, if the number of existing crops is \(n\) and if a farmer does not have access to a particular market, then this agent will only be able to form a portfolio of at most \(n-1\) crops. The same happens when considering other barriers that limit the availability of crops, such as technological constraints. The important consequence of the existence of these barriers is that the remaining available crops define an efficient frontier because it is always possible to find a combination of the remaining crops that provides the maximum gross margin given a level of business risk. In addition, if farmers have access to the same crops and if they have different land qualities, then they also face a different \(EF\) because the same portfolio of crops will generate a smaller gross margin in the farm with lower land quality.

In order to see how these asymmetries affect the shape of the \(EFs\) faced by farmers, some simulations based on the statistics presented in the Agro Business Consultants have been developed (see the references). The method used to calculate the \(EFs\) in these simulations is exactly the same than the one used in the numerical example presented in Appendix E.

In order to appreciate, in particular, how differences in technological or land quality barriers can change the position of the \(EF\) faced by farmers, consider two farmers who produce the same crops: potatoes and wheat. One of the farmers (referred to as ‘the efficient farmer’) does not have any technological restriction and has a land with good
quality. The other farmer (referred to as ‘the inefficient farmer’) has either a technological restriction (e.g. old agricultural machinery compared to the efficient farmer) or lower land quality. In order to introduce this effect in the analysis, it was assumed that the inefficient farmer obtains only 90% of the gross margin obtained by the other farmer. In other words, a factor equal to 0.9 was applied to the historical gross margin of these crops obtained by the efficient farmer. The EFs faced by these farmers are presented in Figure 4.4 (the calculations developed in this simulation are formally presented in Appendix I):

![Figure 4.4 Efficient Frontiers faced by an Efficient and an Inefficient Farmer.](image)

This simulation shows clearly that these farmers face different EFs. In this case the efficient farmer can obtain larger expected gross margin per unit of business risk. This example confirms that the assumption of the existence of a representative farmer hides some important sources of asymmetry like the one associated with the EFs presented in Figure 4.4.
This phenomenon is also verified when considering market barriers. To illustrate this, consider two farmers: one without market barriers who produces wheat and potatoes; and one who faces a market barrier that prevents him/her from producing potatoes. Because the latter cannot produce potatoes, he/she decided to produce oilseed rape instead. This simulation is presented in Figure 4.5 (the calculations developed in this simulation are presented in Appendix J).

![Figure 4.5 Efficient Frontiers of Farmers facing Heterogeneous Market Barriers.](image)

This figure shows that the farmer who faces the market barrier can only obtain low levels of gross margin per unit of business risk with respect to the other farmer. This happens because oilseed rape has a much lower level of gross margin than potatoes. This finding also supports the idea that the assumption of the existence of a representative farmer is too strong. In fact, Figure 4.5 suggests that market barriers constitute an important source of asymmetry in the context of the EV approach (see Section 3.3.2.2).
4.3.1.2 The Behavioural Component of the MEFT

According to the MEFT, farmers who have limited cropping choices (i.e. farmers who face market and material resource barriers preventing them from producing crops with high levels of gross margin) will always choose portfolio of crops with EFs that allow them to obtain higher levels of gross margin and lower levels of business risk. For example, suppose that a particular farmer can only produce crops $a$, $b$ and $c$. This farmer can form four different portfolios from these crops: (i) a portfolio composed of crops $a$, $b$ and $c$; (ii) a portfolio composed of crops $a$ and $b$; (iii) a portfolio composed of crops $a$ and $c$; and (iv) a portfolio composed of crops $b$ and $c$. If the latter portfolio is the one that allows the farmer to obtain the highest expected gross margin and the lowest level of business risk, then according to the MEFT this is the portfolio that the farmer will choose.

This assumption is consistent with the non-satiation assumption on preferences used in microeconomic theoretical analysis (Morgan et al., 2006). This assumption says that individuals are rational in the sense that they will always choose combinations of income and business risk that increase their utilities. This is formally shown in Figure 4.6.
Point $a$ in this figure shows the initial combination of expected gross margin and business risk reported by the portfolio of crops chosen by a particular farmer which allows her/him to reach the indifference curve $E(U(\pi))_0$. This point defines four regions that have been named $I$, $II$, $III$, and $IV$, and they will be used to analyse farmer’s rationality. In particular, notice that it is not rational for this farmer to choose any portfolio of crops that are located in region $IV$ such as that given in point $c$. This is because this region is associated with lower levels of gross margin and higher levels of business risk. As a consequence, if this farmer chose a portfolio of crops consistent with point $c$ in this region, then this individual would only be able to reach the indifference curve $E(U(\pi))_1$. However, this indifference curve provides the farmer a lower level of utility than $E(U(\pi))_0$ for any level of business risk.

The opposite happens in region $I$. That is, it is always rational to choose a portfolio of crops in this region because this region is associated with higher levels of expected gross margin and lower levels of business risk (e.g. point $b$ in Figure 4.6). This implies that moving to this region from point $a$ is preferred as this allows the farmer to reach
higher levels of expected utility. In the figure, this higher level of expected utility is given by $E(U(\pi))$. In summary, the non-satiation assumption postulates that risk averse farmers will always try to form portfolios of crops located in region $I$ as this permits them to improve their current condition.

### 4.3.1.3 The Consequential Component of the MEFT

According to the MEFT, when the descriptive and behavioural components of this theory both hold and, in addition, when farmers are all risk averse and have the same attitudes toward risk, a theoretical optimal path reflecting a negative relationship between expected gross margin and business risk arises. This theoretical relationship was called in this thesis the *Efficient Portfolio Line (EPL)* and is explained as follow (a mathematical derivation of the *EPL* is presented in Appendix H).

In order to explain the concept of *EPL*, let us formalise the ideas presented so far. The MEFT proposed in this thesis allows us to infer this relationship under the following assumptions: 
(i) risk averse farmers have the same coefficient of absolute risk aversion (i.e. the same value of the coefficient of absolute risk aversion and, therefore, their indifference curves have the same slope as can be inferred from Equation F.2 in Appendix F); 
(ii) these individuals face different market and material resources barriers that prevent them from choosing crops with very high levels of gross margin (i.e. the descriptive component of the MEFT holds); and 
(iii) maximising gross margin and minimising business risk are included in the set of farmers’ goals (i.e. the behavioural component of the MEFT holds).
The first assumption enables the identification of behavioural differences across farmers that are explained by differences of market and material resources barriers, but not by differences of attitudes towards risk. That is, this assumption makes it possible to identify how farmers strategically change their optimal selection of portfolio of crops when they face these barriers. The second assumption was introduced with the objective of identifying strategic behaviour of farmers who can only produce relatively similar crops in terms of gross margin and business risk. The reason is to avoid the incidence of outliers arising when farmers can produce crops with high gross margin. This is due to the fact that these crops are also very risky enterprises (i.e. they are crops with high variance of gross margin. See Footnote 2 in Chapter 2). As a consequence, when they are introduced into portfolios of crops, the gross margin and level of risk of these portfolios increase dramatically. This, in turn, is captured as an outlier point in the geometric space presented in Figure 4.3 above, with reference to farmers who can only produce crops having low levels of gross margin and business risk. This assumption is, however, relaxed in Section 4.3.3. Finally, the last assumption was adopted with the objective of introducing rationality in terms of farmers’ strategic cropping decisions. This is because, as explained in Section 4.3.1.2, this assumption is consistent with the non-satiation assumption on preferences (Morgan et al., 2006).

The MEFT proposed in this thesis postulates that when the three assumptions described above hold, farmers form portfolio of crops with efficient frontiers that allow them to maximise their expected utility (defined under the EV approach as shown in Section 3.3.2.3) in area I of Figure 4.6. To understand this, consider the following example. Suppose that there are three farmers who face market barriers preventing them from adopting crops with high gross margin. Consequently, they can only produce traditional crops. However, they cannot produce the same traditional crops because they also face
different resource barriers such as land quality. As a result, Farmer 1 can only produce crops \(a\) and \(b\); Farmer 2 can only produce crops \(a\) and \(c\); and Farmer 3 can only produce crops \(b\) and \(c\). Because these farmers can form portfolio of crops composed of different traditional crops, they face different \(EFs\). Assume that Farmer 1 is the one who reaches the highest efficient frontier (i.e. \(EF_1\)) and Farmer 3 is the one who reaches the lowest efficient frontier (i.e. \(EF_3\)). This means that the portfolio of crops composed of crops \(a\) and \(b\) (the portfolio of Farmer 1) is the one that achieves the higher level of expected gross margin per unit of business risk. In contrast, the portfolio of crops composed of crops \(b\) and \(c\) (the portfolio of Farmer 3) is the one that achieves the lowest level of expected gross margin per unit of business risk. This could reflect the fact that Farmer 1 is the most efficient and farmer 3 the least efficient. Figure 4.7 shows the efficient frontiers of these three farmers:

![Efficient frontiers of Farmers 1, 2 and 3.](image)

In this figure, Farmer 3 cannot reach the efficient frontiers \(EF_1\) or \(EF_2\) because he/she can only produce crops \(b\) and \(c\) as a consequence of the resource barriers that he/she faces. Because this farmer can only produce these crops, he/she can only form a
portfolio composed of these crops which is associated with the efficient frontier $EF_3$ (Appendices E, I, J and K explain how the $EF$ is generated when farmers produce two crops). However, this farmer still has some choices in terms of the way in which crops $b$ and $c$ are mixed in the portfolio (a formal description of this choice is given in the example presented in Appendix E). For example, if this farmer covers, say, 20% of the land with crop $b$ and 80% of the land with crop $c$, then she/he will be able to reach a particular point on the $EF_3$ such as point $i$ in Figure 4.7. In contrast, if this farmer covers, say, 70% of the land with crop $b$ and 30% of the land with crop $c$, then she/he will be able to reach another point on the $EF_3$ such as point $j$. It is important to stress the fact that this farmer cannot, for example, reach point $k$ because this point belongs to another efficient frontier (i.e. $EF_2$) which only arises when forming a portfolio formed of crops $a$ and $c$. However, crop $a$ is not available for this individual.

Which point would Farmer 3 choose? Point $i$ or point $j$? As explained in detail in Appendix E, this will depend on his/her attitude towards risk. That is, on the value of the coefficient of absolute risk aversion of this farmer. This is illustrated in Figure 4.8 (the $EF_1$ and the $EF_2$ were omitted in this figure with the purpose of focusing the analysis on the available choices of Farmer 3. However, the same analysis is valid for the other farmers).
To understand this figure, remember that the EV approach discussed in Section 3.3.2.2 assumes that farmers care about maximising expected gross margin and minimising business risk simultaneously. That is, they care about maximising the following expected utility function (see part (b) of Section 3.3.2.3):

\[ E(U(\pi))_3 = E(\pi) - r_a V(\pi)/2 \]  

(4.1)

where \( E(U(\pi))_3 \) is the expected utility function of Farmer 3. The EV approach argues that farmers maximise their expected utility at the point where the associated indifference curve (i.e. the combination of expected gross margin and business risk that reports the same levels of expected utility) is tangent to the efficient frontier. In order to identify this optimal point for Farmer 3, let us derive the indifference curves associated with points \( i \) and \( j \) in Figure 4.8. The indifference curve associated with Point \( i \) is obtained by fixing the level of expected utility in the expected utility function that is consistent with this point. Let \( E(U(\pi))_{3(0)} \) be this fixed level of expected utility. By
rearranging Equation 4.1, the indifference curve that is consistent with Point \( i \) in Figure 4.8 is given by:

\[
E(\pi) = E(U(\pi))_{3(i)} + r_{a(i)} \cdot V(\pi)/2
\] (4.2)

where \( r_{a(i)} \) is the coefficient of absolute risk aversion that is associated with Point \( i \) (this idea is explained below). Using the same approach, the indifferent curve that is consistent with Point \( j \) in Figures 4.8 is given by:

\[
E(\pi) = E(U(\pi))_{3(j)} + r_{a(j)} \cdot V(\pi)/2
\] (4.3)

Where \( E(U(\pi))_{3(j)} \) is the fixed level of expected utility that is consisted with Point \( j \), and \( r_{a(j)} \) is the coefficient of absolute risk aversion that is associated with this point.

The indifference curve associated with Point \( i \) (i.e. Equation 4.2) is represented in blue in Figure 4.8. In contrast, the indifference curve associated with Point \( j \) (i.e. Equation 4.3) is represented in red in Figure 4.8. Note that the maximisation process at Point \( i \) requires a stepper indifference curve than at Point \( j \). Otherwise, the curve in blue could not be tangent to the \( EF_3 \) in that point. Because the slope of the indifference curve is given by the coefficient of absolute risk aversion as can be seen in Equations 4.2 and 4.3, this implies that \( r_{a(i)} > r_{a(j)} \). The interpretation of this result is that the point chosen by Farmer 3 on the \( EF_3 \) will depend on his/her attitude towards risk. If this individual is “very risk averse” (i.e. if his/her coefficient of absolute risk aversion is \( r_{a(i)} \)) then he/she will choose Point \( i \) because it is at this point where he/she can maximise his/her expected utility when his/her coefficient of absolute risk aversion is \( r_{a(i)} \). In contrast, when this individual is “risk averse, but not very risk averse” (i.e. if his/her coefficient
of absolute risk aversion is \( r_{a(j)} < r_{a(i)} \) then he/she will choose Point \( j \). The same analysis is valid for the other farmers. However, their choices are limited by their respective \( EFs \): Farmer 2 will choose a point on the \( EF_2 \) that is consistent with his/her attitude towards risk; and Farmer 1 will choose a point on the \( EF_1 \) that is consistent with his/her particular attitude towards risk.

In summary, farmers can only choose points on their respective \( EFs \) (e.g. Farmer 3 cannot choose a point on the \( EF_1 \) for example), and the point that they choose in their \( EFs \) depends on their attitudes towards risk. Let us now use these concepts to explain how the \textit{Efficient Portfolio Line (EPL)} predicted by the MEFT arises when the descriptive and the behavioural components of the theory hold, and when farmers have all the same coefficient of absolute risk aversion.

From the previous discussion it is inferred that when farmers have the same attitude towards risk, they have indifference curves with the same slope. In terms of the example of Farmers 1, 2 and 3, this implies that they maximise their expected utilities in points of their \( EFs \) that have the same slope. This is shown in Figure 4.9
According to this figure, the three farmers have the same attitudes toward risk. As discussed above, this implies that they have the same coefficient of absolute risk aversion and this, in turn, means that their indifference curves have the same slope. Because Farmer 1 can only choose points on the $EF_1$, he/she will choose point $w$ because this is the only point that is consistent with his/her attitude towards risk. Likewise, Farmer 2 will choose point $v$ on the $EF_2$, and Farmer 3 will choose point $u$. In other words, Farmer 1 will choose a combination of crops $a$ and $b$ that allows him/her to reach Point $w$; Farmer 2 will choose a combination of crops $a$ and $c$ that allows him/her to reach Point $v$, and farmer 3 will choose a mix of crops $b$ and $c$ that allows him to reach Point $u$.

As can be inferred from Figure 4.9, an important consequence arises when assuming that farmers have the same attitude towards risk (i.e. the consequential component of the MEFT). That is, the portfolios of crops chosen by farmers under these assumptions
achieve levels of gross margin and business risk that define an optimum path that represents their optimal decisions under different EFs. In this thesis this path was termed the Efficient Portfolio Line (EPL) and is the line that joins the optimal points $u$, $v$ and $w$. This line is shown in Figure 4.10 in red (a mathematical derivation of this curve is presented in Appendix H).

![Efficient Portfolio Line](image)

Figure 4.10 The Efficient Portfolio Line.

The existence of the EPL means that it is no longer valid to consider a single farmer as a representative agent, even when farmers have the same coefficient of absolute risk aversion (this concept is formally defined in Section 3.3.2.1 and Appendix D). This is because the introduction of heterogeneous barriers and land qualities makes optimal decisions depart from point $a$, as described in Figure 4.3, along the EPL, as described in Figure 4.10. In other words, having identical attitudes toward risk does not guarantee the existence of a representative farmer.
This theoretical finding was used to define the first hypothesis established for the current research which was named the hypothesis of optimum path (HOP). This hypothesis postulates that risk-averse farmers having the same attitudes toward risk but facing different market and material resources barriers preventing them from adopting crops with high gross margin, choose portfolio of crops achieving expected gross margins and business risk along a theoretical optimal path (i.e. the efficient portfolio line, EPL). In order to test the HOP, the following null and alternative hypotheses were specified:

H₀: If risk-averse farmers have the same coefficient of absolute risk aversion, then the crop allocations chosen by them do not define a path (i.e. the EPL) representing their optimum decisions when facing different restrictions preventing them from adopting crops with high gross margin.

H₁: If risk-averse farmers have the same coefficient of absolute risk aversion, then the crop allocations chosen by them define a path (i.e. the EPL) representing their optimum decisions when facing different restrictions preventing them from adopting crops with high gross margin.

It is important to clarify that this hypothesis is conditional upon two conditions: (i) farmers are risk averse; and (ii) all farmers have the same coefficient of absolute risk aversion (i.e. they have the same attitudes towards risk). The first condition can be considered as a reasonable assumption for the case of the ESBF as they have chosen crops with relatively low levels of business risk in response to the closure of the ASBF. This was formalised as the second hypothesis established for the current research which
was named the hypothesis of risk aversion (HRA). In order to test the HRA, the following null and alternative hypotheses have been specified:

\[ H_0: \text{The ESBF are not risk averse.} \]

\[ H_1: \text{The ESBF are risk averse.} \]

The condition of similar attitudes towards risk, on the other hand, is also reasonable for the case of the ESBF because they chose similar crops to replace sugar beet. As pointed out above, this can be explained by the institutional theory presented in section 3.7. This approach is, therefore, used to support the hypothesis that the ESBF have similar attitudes towards risk. This hypothesis was named the hypothesis of similar coefficient of absolute risk aversion (HSCRA) and corresponds to the third hypothesis established for the present research. In order to test the HSCRA, the following null and alternative hypotheses were specified:

\[ H_0: \text{The ESBF do not have a similar coefficient of absolute risk aversion.} \]

\[ H_1: \text{The ESBF have a similar coefficient of absolute risk aversion.} \]

### 4.3.2 Introducing the Multiple Goals Approach and the Theory of Planned Behaviour

The analyses of the EFL developed in Section 4.3.1 and Appendix H assume that farmers’ objective is to maximise expected gross margin and to minimise business risk
simultaneously. That is, these analyses were based on the assumption that farmers are expected gross margin maximisers (this concept belongs to the EV approach as is formally defined and discussed in Section 3.3.2.2). However, maximising expected gross margin and minimising business risk are only two possible farmers’ goals of many, a fact that was originally pointed out by Gasson (1973) (see the discussion of the multiple goals approach presented in Section 3.4.1). For example, farmers could have the goal of maintaining family tradition or maintaining environmental quality which are not necessarily related to the objectives of minimising business risk or maximising expected gross margin. In addition, a farmer could be willing to give up some levels of gross margin in order to have more time for his/her family. Likewise, farmers’ strategic decision could also be affected by social and psychological factors that are not considered in the analyses of the EFL developed in Section 4.3.1 and Appendix H (this idea was introduced in Section 3.5.1 in the context of the theory of planned behaviour). For example, a farmer could primarily be interested in maximising expected gross margin and minimising business risk simultaneously. But if he/she is strongly influenced by the opinion of his/her neighbours, then decisions made by these individuals could affect the cropping decisions made by this farmer.

The objective of this section is to investigate theoretically how these non-economics factors could affect farmers’ cropping decisions. In particular, the aim is to determine whether these factors could cause deviations around the EPL. Identifying these changes has been the basis for the proposal of a hypothesis that this thesis tests in the empirical part of the current investigation.

In order to determine theoretically whether non-economic factors could cause deviations around the EFL, an analytical approach that extends the behavioural component of the
MEFT described in Section 4.3.1.2 was adopted. This approach is explained as follows. As discussed in Section 4.3.1.2, the MEFT assumes that farmers care about maximising expected gross margin and minimising business risk simultaneously. That is, they care about maximising their expected utility defined under the EV approach (see Section 3.3.2.3). This objective function is presented in Expression F.2 in Appendix F and corresponds to \( E(U(\pi)) = E(\pi) - r_a V(\pi)/2 \) where \( E(U(\pi)) \) stands for expected utility, \( E(\pi) \) denotes expected gross margin, and \( V(\pi) \) represents business risk (see Footnote 2 in Chapter Two). As explained in Section 3.3.2, this function implicitly considers the objectives of maximising expected gross margin \( E(\pi) \) and minimising business risk \( V(\pi) \). This is because in this function the expected utility increases as the expected gross margin increases and decreases as business risk increases when individuals are risk averse\(^{10}\) (when the coefficient of absolute risk aversion \( r_a \) defined in Section 3.3.2.1 and Appendix D is positive). But this implies that the expected utility is maximised when the expected gross margin is maximised and when business risk is minimised.

In order to identify whether non-economic drivers cause deviations around the EPL, assume now that farmers not only consider the objectives of maximising expected gross margin and minimising business risk simultaneously, but also another objective denoted by \( \theta \). This objective was introduced into the expected utility function described above as follows:

\[
E(U(\pi)) = E(\pi) - \frac{r_a}{2} V(\pi) + \theta \quad (4.4)
\]

In order to investigate how a farmer maximises this version of the expected utility function, remember that this maximisation problem is found at the point where the
associated indifference curve is tangent to the efficient frontier (see Section 4.3.1.3). As shown in the derivation of Equations 4.2 and 4.3 above, the indifference curve is obtained when fixing a level of expected utility. Let $E_i(U(\pi))$ be this fixed level of expected utility. By rearranging terms in Expression 4.4, the indifference curve is the defined as:

$$E(\pi) = E_i(U(\pi)) + \frac{r_a}{2}V(\pi) - \theta$$  

(4.5)

where the slope is $r_a/2$ and the intercept is given by $E_i(U(\pi)) - \theta$. Figure 4.11 shows how the presence of $\theta > 0$ changes the optimal crop allocation chosen by this farmer:

![Figure 4.11 Effect of a Non-Economic Driver on the Optimal Crop Allocation chosen by a Farmer.](image)

Point $a$ in this figure shows the optimal decision of a farmer who only cares about maximising expected gross margin and minimising business risk. This is why this individual is located along the $EPL$ as discussed in detail in Section 4.3.1. However, if this individual also considered the goal $\theta$ shown in Equation 4.5, then he/she would
maximise his/her expected utility at point \( b \). In mathematical terms, this is because the indifference curve shifts down as this change is captured as a decrease in the intercept from \( E(U(\pi)) \) to \( E(U(\pi)) - \theta \). In this case the farmer who considers the non-economic driver \( \theta \) has chosen a portfolio of crops achieving a level of expected gross margin equal to \( E(\pi) \), and a level of business risk equal to \( V(\pi) \). Note that even when this farmer has the same attitude towards risk as the representative farmer (this is because the indifference curves \( E(U(\pi)) \) and \( E(U(\pi))' \) both have the same slope), the portfolio of crops chosen by the former is different from that chosen by the representative farmer (point \( a \) in Figures 4.11). This implies that farmers having the same coefficient of absolute risk aversion but different valuations on non-economic drivers can maximise their utility by choosing different portfolio of crops. As a consequence, the assumption of the existence of a representative agent does not necessarily hold when farmers consider non-economic drivers.

The interpretation of this theoretical and mathematical development is better understood by using an example. Suppose that a particular farmer initially considered only the goals maximising expected gross margin and minimising business risk, simultaneously. Suppose in addition that all the assumptions of the MEFT discussed in Section 4.3.1 hold. As a consequence, this individual is operating at point \( a \) on the EFL in Figure 4.11. Suppose now that this individual, after attending a social meeting with other farmers, realises that he/she is not devoting enough time to his/her family. As a result, he/she decides to introduce this objective into his/her priorities. But this has a cost: devoting more time to the family implies working fewer hours per day in the farm. In order to adjust to this time constraint, the farmer decided to form a portfolio of crops with less time consuming crops. Because less time consuming crops have normally lower levels of expected gross margin and business risk (see the discussion given in...
Section 3.4.2), the resulting portfolio of crops achieves a lower level of expected gross margin and business risk such as that associated with point $b$ in Figure 4.11. This is captured in this figure as a deviation from the $EPL$ because point $b$ is not aligned with this curve. In summary, when the farmer includes the objective of devoting enough time to his/her family, he/she chooses a portfolio of crops achieving lower levels of expected gross margin and business risk which is reflected as a deviation from the $EPL$.

The example presented in the last paragraph was useful to illustrate how some non-economic drivers can cause deviations from the $EPL$ to the left (i.e. deviations in which farmers obtain lower levels of expected gross margin per unit of business risk). However, other types of non-economic drivers can also cause deviations from this curve to the right (i.e. deviations in which farmers obtain higher levels of expected gross margin per level of business risk). This case is shown in Figure 4.12:

![Figure 4.12 Deviation from the $EFL$ to the right.](image)

In order to understand this type of deviation, consider the following example. Suppose an individual who initially cared about maximising expected gross margin and
minimising business risk. As a consequence, he/she was located at point \( a \) on the \( EPL \) presented in Figure 4.12. Suppose now that this farmer considers a new goal which is gaining recognition from his/her referential group. Suppose that this individual, in order to achieve this objective, introduces an innovation that allows him/her to be more efficient in terms of obtaining higher yields per hectare. This change is captured as a deviation from the \( EPL \) to the right because this individual is able to obtain a higher level of expected gross margin per unit of risk such as that associated with point \( b \) in Figure 4.12. This more competitive position, in turn, helps the farmer to obtain recognition from his/her referential group.

The two examples shown in Figures 4.11 and 4.12 suggest therefore that non-economic drivers can generate deviations from the \( EPL \) either to the left or to the right depending on the nature of these drivers. Let us now see the implications of these deviations when considering a population of farmers rather than a single farmer. For this purpose, assume the existence of six farmers named \( a, b, c, d, e \) and \( f \). Assume in addition that these farmers care about maximising expected gross margin and minimising business risk. Suppose that the assumptions of the MEFT hold. As a consequence, these farmers are initially located on the \( EPL \) as shown in Figure 4.13(a).
Suppose now that these farmers not only consider the objective of maximising gross margin and minimising business risk, but also other non-economic drivers. As shown in Figures 4.11 and 4.12, the introduction of these drivers causes deviations from the EPL to the right or to the left depending on the nature of them. Figure 4.13(b) shows how introducing non-economic drivers generates deviations by the farmers considered in this example. According to this figure, farmers $a$, $c$ and $e$ deviate from the EPL to the left meaning that these individuals consider non-economic objectives that can only be achieved by forming portfolios with lower levels of expected gross margin per unit of risk. This is the case presented in Figure 4.11 which shows an example of a farmer who formed a portfolio with lower levels of expected gross margin per unit of risk with the purpose of achieving the objective of devoting more time to his/her family. The rest of the farmers (i.e. farmers $b$, $d$ and $f$), in contrast, deviate from the EFL to the right. This is the case presented in Figure 4.12 which shows an example of a farmer who formed a portfolio with a higher level of expected gross margin with the purpose of achieving the objective of gaining recognition from his/her referential group.
To summarise, the MEFT establishes that risk averse farmers who have the same attitudes toward risk choose a portfolio of crops achieving levels of gross margin and levels of business risk along the *EPL*. This has been extended to hypothesise that deviations around the *EPL* by risk averse farmers with the same attitudes toward risk are explained, among others, by differences of non-economic drivers across these individuals. This idea was formalised in a hypothesis that was called the Hypothesis of Non-economic Drivers (HNE). This hypothesis establishes that farmers’ cropping decisions are influenced by non-economic drivers. This is the fourth hypothesis proposed for the present research. In order to test the HNE, the following null and alternative hypotheses have been specified:

\[ H_0: \text{Farmers’ cropping decisions are not influenced by non-economic drivers.} \]

\[ H_1: \text{Farmers’ cropping decisions are influenced by non-economic drivers.} \]

### 4.3.3 Introducing Dynamic Capabilities

According to the analysis conducted in Section 3.2.3, one of the factors that helps explain the low gross margin cropping choice made by the ESBF is the lack of opportunities to develop dynamic capabilities. This is because there are a number of determinants of dynamic capabilities that probably were not available for these farmers at the moment when the SRR was implemented. For the purpose of the present section, these have been classified as determinants associated with individual characteristics (i.e. self-motivation; pre-existing knowledge of market and productive process of crops with high levels of gross margin; and attitudes towards risk); those associated with social
interaction (i.e. participation in collaborative inter-firm alliances and social networks); and those associated with material resources (i.e. capital, technology and land quality).

There is an important question related to these determinants in the context of the proposed multivariate model. That is, how farmers would behave if these determinants were available? The objective of this section is to predict this behaviour from the proposed multivariate model and, in particular, from the MEFT.

### 4.3.3.1 Introducing Determinants associated with Individual Characteristics

In order to predict the effect of introducing determinants of dynamic capabilities associated with individual characteristics (i.e. self-motivation; pre-existing knowledge of market and productive process of crops with high levels of gross margin; and attitudes towards risk), it is assumed for simplicity that all farmers have portfolios of crops achieving expected gross margin and business risk along the EPL (see Figure 4.13(a)). That is, it is assumed that these individuals have the same attitudes towards risk; they only consider gross margin and business risk when making their cropping decisions (i.e. farmers’ goals and social-psychological variables are not involved in their cropping decisions); and they face heterogeneous market and material resources barriers preventing them from producing crops with high gross margin. Based on these assumptions, introducing determinants of dynamic capabilities associated with individual characteristics would in theory generate deviations around the EPL as shown in Figure 4.13(b) above. For example, it was discussed in Chapter Three that self-motivation helps farmers to develop absorptive capacity (see Section 3.2.2) and this, in turn, allows these individuals to obtain relevant information to adjust in response to exogenous shocks. Therefore, self-motivated farmers are in theory more informed than
non-motivated ones. It is anticipated, therefore, that the former obtain higher gross margin per unit of risk as a consequence of their informational advantage.

A similar conclusion can be obtained when considering farmers’ attitudes toward risk. That is, risk aversion affects farmers’ willingness to innovate: a farmer who is risk averse is less inclined to be involved in innovation that implies some degree of risk. As a result, it is anticipated that this farmer obtain lower levels of gross margin per unit of business risk in relation to a risk lover farmer.

Finally, pre-existing knowledge of market and productive process of crops with high gross margin cannot produce deviation around the \( EPL \) in the context of the MEFT. This is a consequence of the assumption of market and material resources barriers preventing farmers from adopting crops with high gross margin because this affects all farmers: farmers with or without pre-existing knowledge of market and productive process of crops with high gross margin cannot adopt these crops because they face these barriers. As a result, they cannot improve their competitive position on or around the \( EPL \) when having this knowledge.

The analysis conducted so far was formalised in a hypothesis that was named the Hypothesis of determinants associated with Individual Characteristics (HIC). This is the fifth hypothesis proposed for the current research. The HIC postulates that when farmers face barriers preventing them from producing crops with high gross margin, only differences in self-motivation and attitudes towards risk generate deviations around the \( EPL \). In order to test the HIC, the following null and alternative hypotheses have been specified:
H₀: Differences of determinants of dynamic capabilities associated with individual characteristics across farmers do not generate deviations around the EPL.

H₁: Among the determinants associated with individual characteristics, only differences of self-motivation and attitudes towards risk generate deviations around the EPL.

4.3.3.2 Introducing Determinants associated with Social Interaction

In order to identify the effect of introducing determinants associated with social interaction on farmers’ cropping decisions, it will be assumed again that these individuals have portfolios of crops achieving expected gross margin and business risk along the EPL. Based on this assumption, it can be shown that the effects of introducing these determinants depend on the nature of the social interaction. To see why, consider the discussion on dynamic capabilities presented in Section 3.2.2. According to this discussion, social interaction (i.e. participation in collaborative inter-firm alliances and social networks) can help farmers to develop absorptive and innovative capacities. If the objective of these social interactions is to obtain the information needed to adopt crops with high levels of gross margin, then introducing them into the analysis does not produce any effect in terms of the EPL. This is because it was assumed that farmers whose portfolios of crops are located along this line, face market and material barriers preventing them from adopting crops with high gross margin. In contrast, if these social interactions are formed with the objective of providing countervailing power in the relationship between supplier and retailers, then they could eventually help farmers to improve their competitive position in terms of obtaining better prices for current production. As a consequence, it is expected to find that alliances formed with the
purpose of gaining countervailing power can generate deviations around the \textit{EPL}. Finally, if collaborative alliances were formed with the objective of reducing average cost by means of economies of scale, then these alliances would also generate deviations around the \textit{EPL}. This is because these farmers would be able to gain efficiency and, therefore, higher gross margin per unit of business risk.

These theoretical behavioural responses were formalised in a hypothesis that was called the Hypothesis of Social Interaction (HSI). This is the sixth hypothesis proposed for the current research and establishes that when farmers face market and material resources barriers preventing them from producing crops with high gross margin, introducing social interaction can only generate deviations around the \textit{EPL} when they help farmers either to gain negotiation power or to gain efficiency. In order to test the HSI, the following null and alternative hypotheses have been specified:

\begin{align*}
\text{H}_0 & : \text{Differences of determinants of dynamic capabilities associated with social interaction across farmers cannot generate deviations around the } \textit{EPL}. \\
\text{H}_1 & : \text{Differences of determinants of dynamic capabilities associated with social interaction across farmers generate deviations around the } \textit{EPL} \text{ when they help farmers either to gain negotiation power or to gain efficiency.}
\end{align*}

\textbf{4.3.3.3 Introducing Determinants associated with Material Resources}
Introducing determinants of dynamic capabilities associated with material resources into the analysis is equivalent to removing capital, technological and land quality barriers from the proposed multivariate model. This is because these barriers appear only when farmers do not have access to material resources such as capital. The way in which these individuals respond to the introduction of this type of determinants depends, however, on whether they face market barriers preventing them from producing crops with high gross margin.

To understand this, assume again that farmers have chosen portfolios of crops that are initially located along the \textit{EPL}. The assumptions are, then, that all farmers care only about maximising gross margin and minimising business risk, that all these individuals are risk averse and have the same coefficient of absolute risk aversion, and that all of them face different market and material resources barriers. These farmers can be classified in two different groups, namely: (i) individuals who only face material resource restrictions; and (ii) individuals who face both material resource restrictions and market barriers. They are described as follows.

a) \textbf{Individuals who only face Material Resource Restrictions}

This group of farmers corresponds to those individuals who face material resource restrictions (i.e. capital, technological and land quality barriers) but not market barriers preventing them from producing crops with high gross margin. For example, crops with high gross margin require expensive and specific machinery that cannot be obtained when facing capital restrictions. If these farmers were given the material resources needed to develop dynamic capabilities, then they would deviate from the \textit{EPL} with the
objective of introducing crops with higher levels of gross margin into their portfolio of crops. That is, they would be able to create competitive advantage in the market of these crops.

To illustrate this, let us consider the following simulation that was obtained using a similar approach than the one adopted in the examples given in Appendices E, I and J. Consider the case of a farmer who initially produced wheat and oilseed rape (this portfolio formed of wheat and oilseed rape is referred to as the original portfolio of crops). Assume that this farmer faced material resource barriers (but not market barriers) preventing him/her from producing onions. Finally, assume that this individual, in response to the introduction of material resources, replaced oilseed rape with onions (this portfolio formed of wheat and onions is referred to as the new portfolio of crops). This simulation is presented in Figure 4.14 (the calculations developed in this simulation are presented in Appendix K).
Figure 4.14 The Case of a Farmer who faces Material Restrictions, but not Market Barriers.

This figure shows two EFs referred to as $EF_0$ and $EF_1$. The $EF_0$ is presented in red and corresponds to the efficient frontier of the original portfolio of crops. The $EF_1$, on the other hand, is presented in blue and corresponds to the efficient frontiers of the new portfolio (i.e. the portfolio that the farmer formed by replacing oilseed rape with onions in response to the introduction of material resources). In this figure the farmer initially produced wheat and oilseed rape because he/she faced material resource barriers that prevented him/her from adopting onions. As a consequence, this individual maximised his/her expected utility at point $a$ where the indifference curve $E(U(\pi))_0$ is at point $a$ tangent to the efficient frontier $EF_0$. Note that because it was assumed that this farmer only cared about maximising expected gross margin and minimising business risk simultaneously, point $a$ has to be located along the $EPL$ depicted in violet (a formal explanation of why point $a$ is located on the $EPL$ is presented in Section 4.3.1 and in Appendix H). Note in addition that point $a$ reports a level of expected gross margin equal to £378/ha and a level of business risk equal to £$^2$17,598/ha$^2$ (these numbers are...
presented in red in the axes of Figure 4.14). According to Table K.2 in Appendix K, these levels of expected gross margin and business risk can only be achieved by forming a portfolio composed of 70% wheat and 30% oilseed rape. This means that the farmer initially maximised his/her expected utility at point $a$ by choosing this combination of crops.

Suppose now that the farmer is given all the material resources needed for the production of onion. Because this crop has higher levels of expected gross margin and business risk than oilseed rape (see Table K.1), the resulting portfolio when replacing the latter crop with onions has an $EF$ that achieves higher levels of expected margin and business risk (curve $EF_1$ in blue in Figure 4.14). In this new $EF$, the farmer maximises his/her new level of expected utility at point $b$ where the indifference curve $E(U(\pi))_1$ is at point $b$ tangent to the efficient frontier $EF_1$. Note that this point reports a level of expected gross margin equal to £1,037/ha and a level of business risk equal to £25,299/ha$^2$ (these numbers are presented in red in Figure 4.14). According to Table K.3, the farmer can obtain these levels of expected gross margin and business risk by forming a portfolio composed of 50% wheat and 50% onions.

In summary, the farmer adjusted to the removal of material resource barriers by changing the composition of the portfolio of crops from a portfolio formed of 70% wheat and 30% oilseed rape to a portfolio formed of 50% wheat and 50% onions. This change is captured in Figure 4.14 as a deviation from the $EPL$ depicted in violet from point $a$ to point $b$. This strategic behavioural prediction was formalised in a hypothesis referred to as the hypothesis of adaptation by departing from the $EPL$ (HAD). This hypothesis establishes that farmers, in response to the removal of material resource restrictions, depart from the $EPL$ by chosen portfolios achieving higher levels of
expected gross margin and business risk. In order to test the HAD, the following null and alternative hypotheses were specified:

\[ H_0: \text{Farmers who do not face market barriers do not depart from the EPL in response to the removal of material resources barriers.} \]

\[ H_1: \text{Farmers who do not face market barriers depart from the EPL in response to the removal of material resources barriers.} \]

b) **Individuals who face both Material Resource Restrictions and Market Barriers**

The second group of farmers that are allocated on the EPL corresponds to those individuals who face both material resource restrictions and market barriers. Notice that these farmers cannot access crops with high levels of gross margin even when removing their material resource restrictions because they also face market barriers. Therefore, introducing material resources can only help them to improve their competitive condition by gaining efficiency or by selecting alternative available crops having slightly higher levels of gross margin (but not crops with high levels of gross margin). Because in this case farmers remain within the same structure of EFs associated with crops having low levels of gross margin, it is expected to find that these individuals will move upwards along the EPL when removing material resources barriers. This case is shown in Figure 4.15:
This figure shows that before introducing material resources, a particular farmer maximises his/her utility at point \( a \) where the efficient frontier \( EF \) is at tangent \( a \) to the indifference curve \( E(U(\pi)) \). As a consequence of the introduction of material resources, this farmer does not face capital, technological or land quality restriction any longer. As a result, it is expected to find that this agent will increase his/her utility by moving along the \( EPL \) until reaching point \( b \), where the efficient frontier \( EF' \) is at \( b \) tangent to the indifference curve \( E(U(\pi))' \). This change, therefore, allows the farmer to choose a portfolio of crops achieving a higher level of expected gross margin and a lower level of business risk. This farmer, in the context of the MEFT, will always choose point \( b \) after the introduction of material resources because the non-satiation assumption discussed in Section 4.3.1.2 implies that this agent is rational and, as a consequence, she/he always has an incentive to increase gross margin and to reduce business risk.

This strategic behavioural prediction was formalised in a hypothesis referred to as the hypothesis of adaptation along the \( EPL \) (HAE). This is the eighth hypothesis established for the current research and postulates that farmers who face both market and material

Figure 4.15 The Case of a Farmer who faces both Material Resource Restrictions and Market Barriers.
resource barriers move upwards along the \( EPL \) in response to the removal of the latter.

In order to test the HAE, the following null and alternative hypotheses were specified:

\[ H_0: \text{Farmers who face market barriers preventing them from producing crops with high levels of gross margin do not move upward along the } EPL \text{ in response to the removal of material resources barriers.} \]

\[ H_1: \text{Farmers who face market barriers preventing them from producing crops with high levels of gross margin move upward along the } EPL \text{ in response to the removal of material resources barriers.} \]

Finally, it is important to highlight the fact that if either the HAE or the HAD is not supported by the data, then this implies that behavioural responses to the introduction of material resources are also determined by non-economic drivers. Determining these non-economic drivers is one of the aims of the present research.

**4.4 Farmers’ classification according to their strategic behaviour**

The analysis developed in the previous section was introduced with the purpose of identifying different possible strategic behavioural responses when introducing the different approaches considered by the proposed multivariate model (see Figure 4.2). The current section considers these theoretical behavioural responses with the objective of proposing a novel typology to classify farmers according to their strategic behaviour.

In order to show why this novel typology is needed for the present investigation, the section starts by reviewing two existing typologies that have normally been used to
classify individuals according to their strategic behaviour: the Ansoff’s matrix and the Miles and Snow’ typology. It is also explained why these typologies are not appropriate in the context of the MEFT proposed in the current research. The section finishes by introducing the novel typology which was called in the present research the Income-Risk matrix typology.

4.4.1 Exiting Typologies for classifying Individuals according to their Strategic Behaviour.

4.4.1.1 Ansoff’s Matrix

As explained in Chapter Three, Ansoff (1957) proposed a method for measuring the competitive potential of alternative product-market strategies (see the discussion on the classical approach of strategy developed in Section 3.2.1). This classification is not appropriate to study the case of the ESBF in the context of the proposed multivariate model because the Ansoff’s matrix assumes that the objective of managers is to maximise gross margin. However, the proposed multivariate model presented in Figure 4.2 shows that gross margin maximisation is only one of many other possible targets that farmers could consider when establishing their crops. For example, Ansoff’s Matrix cannot be used to describe the optimal strategy of farmers whose objective is to maintain family tradition. Likewise, this typology cannot be used to describe the optimal strategy of farmers whose objective is to maintain nature values and to protect the environment.

4.4.1.2 The Miles and Snow’ typology
Miles and Snow (1978) developed a typology to classify organisations in terms of the degree of aggressiveness of the strategies chosen by them in dynamic environments. The advantage of this classification is that it links an organisation’s environment and internal resources with different types of strategic behaviour (Desarbo et al. 2005). In particular, this typology allows coupling types of strategic behaviours with different degrees of environment stability (Walker et al., 2003). The three elements of this classification (i.e. strategic behaviour; organisation’s environment; and internal resources) are described as follows.

Regarding strategic behaviour, the types of organisations described by Miles and Snow (1978) correspond to prospectors, defenders, analysers and reactors. Lynch (2009) provides the following definitions for them. Prospectors correspond to organisations that “are involved in growing markets where they actively seek new opportunities through innovation. They are typically flexible and decentralised in their approach to the market and able to respond quickly to change” (p. 464). Defenders are organisations that “produce products or services with the objective of obtaining market leadership. They may achieve their objectives by concentrating on a market niche through specialisation and cost reduction” (p. 464). Analysers are organisations that “seek to expand but also to protect what they already have. They may wait for others to innovate and delay while others prove new market opportunities before they enter” (p. 464). Finally, reactors are organisations that “respond inappropriately to competitors and to the more general environment. They rarely, if ever, take the initiative and, in a sense, may have no strategy: they always react to other strategies. Even if they have a strategy, it is entirely inappropriate to the environment and hence the resulting reactor
organisation is bound to be inadequate” (p. 464). Figure 4.16 shows the main characteristics of these types of organisations:

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Strategic environment</th>
<th>Strategic approach</th>
<th>Resource Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prospector</td>
<td>Growing, Dynamic</td>
<td>Find new opportunities</td>
<td>Flexible production</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exploit and take risks</td>
<td>Innovative with decentralised control</td>
</tr>
<tr>
<td>Defender</td>
<td>Stable</td>
<td>Protect market share</td>
<td>Efficient production</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hold current position</td>
<td>Tight control</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Centralised management</td>
</tr>
<tr>
<td>Analyser</td>
<td>Slow change</td>
<td>Hold market share</td>
<td>Efficient production but</td>
</tr>
<tr>
<td></td>
<td></td>
<td>but with some</td>
<td>with some flexibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>innovation</td>
<td>in new areas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seek market</td>
<td>Tight control in existing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>opportunities but</td>
<td>areas but lower control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>protect existing areas</td>
<td>in new products</td>
</tr>
<tr>
<td>Reactor</td>
<td>Growing or slow</td>
<td>Responding only</td>
<td>Muddled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>to others often late</td>
<td>Centralised</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and inadequate</td>
<td>Slow</td>
</tr>
</tbody>
</table>

Figure 4.16 Miles and Snow’ (1978) Typology of Organisations. Source: Adapted from Lynch, 2009

Regarding the organisation’s environment in the extreme cases (i.e. prospectors and defenders), a prospector strategy is likely to be driven by high perceived uncertainty due to unstable environments. For example, Milliken (1987) found that diversification is associated with firms that perceive high environment uncertainty. Likewise, Tan (1996) and Buchko (1994) found that firms that perceive high environment uncertainty develop strategies associated with innovative, proactive, and risk-taking behaviours. In contrast, a defender strategy is likely to be driven by perceived environment certainty (Walker et al., 2003). Finally, regarding organisation’s internal resources for the extreme cases, a prospector organisation tends to value the resources that enable innovation. In contrast, a defender organization tends to value the resources that enable specialisation and efficiency.
These relationships have been confirmed by some empirical works (see for instance Camelo-Ordaz *et al.*, 2003).

The Miles and Snow’ typology is not suitable for the current research because it cannot capture all possible strategies that are available to farmers in the context of the proposed multivariate model and the MEFT. For example, farmers can eventually change the proportion of crops used in their portfolios in order to reach desirable levels of expected gross margin and business risk without actually changing the composition of these portfolios. Because these farmers did not choose new crops or new markets, this strategy is not captured by the Miles and Snow criterion.

4.4.2 The Income-Risk Matrix

Due to the fact that existing typologies used to classify individuals according to their strategic behaviour cannot be applied in the context of the proposed multivariate model and the MEFT, an alternative new criterion was adopted. Since this criterion was not found in the literature, it was called the Income-Risk Matrix typology in this thesis. It appears that no related academic work has proposed this typology. As a result, the proposed tool constitutes an additional contribution of the present study.

The Income-Risk matrix typology captures changes of expected gross margin and levels of business risk of new portfolios of crops with respect to a referential or initial portfolio. This matrix is presented in Figure 4.17:

<table>
<thead>
<tr>
<th>Business Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smaller business risk</td>
</tr>
<tr>
<td>Income (gross margin)</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>I. Progressive risk saver (PRS)</td>
</tr>
<tr>
<td>III. Regressive risk saver (RRS)</td>
</tr>
<tr>
<td>V. Neutral (NR)</td>
</tr>
</tbody>
</table>

Figure 4.17 The Income-Risk Matrix. Source: Developed by the author.

The centre of this matrix (i.e. region V in the figure) contains the initial levels of expected gross margin and business risk achieved by the original portfolio of crops chosen by a particular farmer. This centre has been named the referential point. In this matrix, a farmer who chooses a portfolio of crops with larger gross margin and smaller business risk with respect to the referential point after an exogenous change is classified as a progressive risk saver farmer (PRS). A farmer who chooses a portfolio of crops with a larger gross margin and a larger business risk after an exogenous change is classified as a progressive risk enlarger farmer (PRE). A farmer who chooses a portfolio of crops with a smaller gross margin and a smaller business risk after an exogenous change is classified as a regressive risk saver farmer (RRS). A farmer who chooses a portfolio of crops with a smaller gross margin and a larger business risk after an exogenous change is classified as a regressive risk enlarger farmer (RRE). Finally, a farmer who chooses a portfolio of crops with the same level of gross margin and same level of business risk with respect to the referential point in response to an exogenous shock is classified as neutral risk farmer (NR).
The way in which farmers can be classified according to this typology is better understood by considering an example. Suppose that before the incidence of a particular exogenous shock a farmer produced a portfolio of crops composed of wheat and carrots. If both gross margin and the business risk of carrots increased after the exogenous shock, then this farmer can maintain the same level of income and business risk of the portfolio as before the shock by either increasing the proportion of wheat, or by introducing a third crop having a lower gross margin and a smaller degree of business risk than carrots. In both cases, if the objective of the farmer was to maintain the same level of business risk and income as before, then this farmer should be classified as NR. In contrast, a RRS would reduce the proportion of carrots after the incidence of the shock or would introduce other crops with low gross margin and low degree of business risk with the objective of obtaining a post-shock portfolio with less gross margin and less level of business risk than before.

It is important to clarify that this classification does not explain why a farmer could be interested in, for example, maintaining the current levels of expected gross margin or business risk. In the context of the proposed multivariate model, this could represent a farmer who wants to maintain family tradition, or could represent a farmer who faces market and material resources barriers preventing him/her from modifying the current levels of expected gross margin and business risk. Likewise, a farmer who increases the level of business risk could reflect, for example, the case of a farmer who became less risk averse or a farmer who was able to remove a market barrier preventing him/her from producing crop with high levels of business risk.

It is evident that while the Income-Risk matrix does not provide an explanation of why farmers could behave as either NF, PRS, PRE, RRS or RRE, this information can be
obtained from the proposed multivariate model and the MEFT. One of the objectives of the current research is therefore to provide a fuller explanation of the farmers’ behaviour by providing a model that classifies the ESBF in the sample according to the Income-Risk matrix criterion. After that, classes of farmers will be coupled with behavioural variables identified from the proposed multivariate model and the MEFT. This analysis is provided in the empirical part of the research.

4.5 Chapter Summary

The objective of the current chapter was to propose a holistic multivariate model that integrates different approaches to study the way in which farmers make cropping decisions. The aim was to use this framework to infer theoretical behavioural patterns across farmers. The approaches considered by this model are: (i) dynamic capabilities; (ii) utilitarian approach; (iii) multiple goals approach; (iv) theory of planned behaviour; (v) existence of market and material resources barriers.

The chapter starts using both the institutional theory and the utilitarian approaches with the purpose of establishing a benchmark condition. This condition corresponds to the theoretical cropping strategic decision made by a representative farmer (i.e. a farmer whose strategic behaviour represents the behaviour of all the farmers in a population of reference). This representative farmer was defined as an individual who is risk averse and has the same coefficient of absolute risk aversion than the rest of the farmers who belong to a population of reference. This definition was adopted to reflect the fact that the ESBF chose similar crops with low levels of gross margin in response to the closure of the ASBF suggesting that these farmers were risk averse and had the same coefficient of absolute risk averse. This idea was formalised as two hypotheses referred to as the
hypothesis of risk aversion (HRA) and the hypothesis of similar coefficient of absolute risk aversion (HSCRA). The benchmark condition established under these hypotheses was useful to infer deviations from the optimal cropping decision made by the representative farmer when introducing the other approaches considered by the proposed holistic multivariate model. It is important to stress the fact that this theoretical abstraction was introduced to infer deviations from the behaviour of the representative farmer. However, the choice made by the ESBF to replace sugar beet could also reflect their limited choice. This implies that these individuals may not necessarily be risk averse.

The first approach used to infer behavioural deviations from the benchmark condition is the market and material resources barriers approach. This approach was introduced with the purpose of representing the realistic fact that farmers normally face different market and material resources barriers such as differences of land quality. When introducing this approach into the benchmark condition, a theoretical behavioural pattern across farmers appeared. The theory that supports this finding was called in this thesis the multiple efficient frontiers theory. This theory postulates that a predictable optimal path can be inferred when risk averse farmers with the same attitudes toward risk (i.e. when the HRA and the HSCRA both hold) face different market and material barriers preventing them from producing crops with high levels of gross margin. According to this theory, a farmer who faces a significant number of market and resource barriers can only reach a less competitive position in this path. This idea was formalised as the hypothesis of optimum path (HOP). This theoretical path was named the efficient portfolio line (EPL) and was used to predict deviations around this line when introducing the rest of the approaches considered by the proposed multivariate model.
The second and third approaches used to infer deviations from the benchmark condition are the multiple goals approach and the theory of planned behaviour. According to the theoretical examination conducted in this chapter, it was determined that differences of farmers’ goals and variables considered by the theory of planned behaviour across farmers generate deviations around the $EPL$. In other words, when farmers not only consider economic objectives when making their cropping decisions but also non-economic considerations (e.g. goals and psychological variables), deviations from the optimal path captured by the $EPL$ are expected to be found. This idea was formalised as the hypothesis of non-economic drivers (HNE).

The fourth approach used to infer deviations from the benchmark condition is the dynamic capability approach. The theoretical development conducted in this chapter revealed that deviations around the $EPL$ can also be observed by farmers who have different capacities to develop dynamic capabilities. In particular, it was inferred that farmers who have differences of self-motivation will choose portfolio of crops achieving different positions around the $EPL$. This idea was formalised as the hypothesis of determinants of dynamic capabilities associated with individual characteristics (HIC). Likewise, it was inferred that deviations around the $EPL$ can also be observed by farmers who form collaborative alliances and participate in social networks with the purpose of either gaining negotiation power or gaining productive efficiency. This idea was formalised as the hypothesis of determinants of dynamic capabilities associated with social interaction (HIS).

The chapter also investigates theoretical strategic choices that farmers could adopt in response to the removal of material resource barriers (e.g. introduction of capital or technologies that could be used to increase land quality). This theoretical exercise was
developed with the objective of identifying the effect of the introduction of specific policy programmes on farmers’ strategic behaviour. Two possible responses were identified from this theoretical development. One of them is a movement along the *EPL* in which farmers facing market barriers try to reach a better competitive position on this line in response to the removal of material resource restrictions. This theoretical response was formalised as the hypothesis of adaptation along the *EPL* (*HAE*). The other response is a movement that departs from the *EPL* reflecting farmers who do not face market barriers and that adjust to the removal of material resource barriers by selecting crops with high levels of gross margin. This theoretical response was formalised as the hypothesis of adaptation by departing from the *EPL* (*HAD*).

Finally, the chapter proposes a new typology used to classify farmers according to their strategic behavioural responses in terms of modifying the levels of expected gross margin and business risk of their portfolio of crops. This novel typology was named the Income-Matrix typology and was adopted to cluster farmers according to their cropping choices, and to classify each cluster according to economic and non-economic considerations.

In summary, the current chapter develops a holistic multivariate model that was used to identify theoretical behavioural patterns across farmers in terms of their cropping strategic choices. These behavioural patterns were formalised as eight testable hypotheses. The objective of the empirical part of this thesis is to test these hypotheses in order to identify and describe the decision making process of the ESBF. The empirical strategy used to test these hypotheses is the focus of the next chapter. That is, the next chapter explains the statistic and econometric approaches adopted in this thesis to test each of the eight hypotheses established in the current investigation.
Chapter Five: RESEARCH METHODOLOGY
The aim of this chapter was to describe the methodology used in the current research. The first part of the chapter outlines the research philosophy and explains why the positivistic approach was adopted. The second part describes the research strategy adopted in the investigation. The third part revises the concept of common methodology biases and explains the possible biases that could be found in the current research. It also explains how potential common methodology biases were minimised when possible. Finally, the last part shows in detail the methods used in the pilot investigation; questionnaire design; sampling; and the methods used to tests the hypotheses established for the research. These hypotheses are listed as follows:

(1) **Hypothesis of risk aversion (HRA)**: The ex-sugar beet farmers of the West Midland region are risk averse.

(2) **Hypothesis of similar coefficient of absolute risk aversion (HSCRA)**: The ex-sugar beet farmers of the West Midlands region have a similar coefficient of risk aversion (this concept is formally defined in Section 3.3.2.1 and Appendix D).

(3) **Hypothesis of optimum path (HOP)**: Risk averse farmers with the same attitudes toward risk but facing different market and material resources barriers preventing them from adopting crops with high levels of gross margin, choose portfolio of crops achieving expected gross margins and business risk along a theoretical optimal path (i.e. the efficient portfolio line, EPL).

(4) **Hypothesis of non-Economic Drivers (HNE)**: Farmers’ cropping decisions are influenced by non-economic drivers (i.e. socio-psychological variables).
(5) **Hypothesis of determinants of dynamic capabilities associated with individual characteristics (HIC):** Among the determinants associated with individual characteristics, only differences of self-motivation and attitudes towards risk generate deviations around the \( EPL \).

(6) **Hypothesis of determinants of dynamic capabilities associated with Social Interaction (HSI):** When farmers face market and material resources barriers preventing them from producing crops with high levels of gross margin, social interaction (i.e. participation in collaborative alliances and social networks) can only generate deviations around the \( EPL \) when it helps them either to gain negotiation power or productive efficiency.

(7) **Hypothesis of adaptation by departing from the \( EPL \) (HAD):** Farmers who do not face market barriers depart from the \( EPL \) by choosing portfolio of crops achieving higher levels of expected gross margin and business risk in response to the removal of material resources barriers.

(8) **Hypothesis of adaptation along the \( EPL \) (HAE):** Farmers who face market barriers preventing them from producing crops with high gross margin choose portfolio of crops that are located upwards along the \( EPL \) in response to the removal of material resources barriers.

Note that the concept of business risk used in some of these hypotheses is formally defined in Footnote 1 in Chapter One. Give the relevance of this concept for this thesis, this definition presented again as follows. Business risk is the aggregate effect of all the
uncertainty influencing the levels of gross margin made by a firm. This comprises production risk arising from weather uncertainty, market uncertainty arising from the unpredictable nature of output prices, institutional risk arising from unpredictable changes of rules affecting production, and personal risk arising from unpredictable events such as illness (Hardaker et al., 1998).

5.1 Research Philosophy and Research Approach

According to Saunders et al. (2009), the data collection technique needed in an investigation depends on the research approach adopted and this, in turn, flows from the research philosophy considered in the research. This idea was represented by these authors as a research process referred to as the “research onion”. This is the research process approach adopted in this investigation and is presented in the following figure.
According to Saunders et al. (2009), before coming to the central point on data collection and data analysis, the superior layers in this representation have to be defined. The way in which these layers were defined in this thesis is explained as follows.
5.1.1 Research Philosophy

The first layer presented in the research process shown in Figure 5.1 is the research philosophy. According to this figure, there are four philosophical positions: positivism; realism; interpretivism; and pragmatism.

The positivism philosophical position or positivist research approach derives from the philosophy of science and uses scientific methods to conduct research. According to Maylor and Blackmon (2005), the positivistic approach hypothesises essential laws from a theory and by means of observation deduces which laws support or reject this theory. That is, this approach identifies causal explanations by means of the validation of relevant hypothesis.

The realism philosophical position postulates that objects have an existence independently of the human mind and our senses provide a way to describe the world. According to Saunders et al. (2009), there are two forms of realism: direct realism; and critical realism. Direct realism argues that our senses portray the world accurately. Critical realism, in contrast, argues that what we experience is based on our sensations and perceptions but not the things in the real world. In other words, the knowledge of reality we have depends on the social actors that were involved in the knowledge derivation process. However, different perceptions of a particular reality might be triangulated to obtain a better (although imperfect) picture of it (Perry, et al. 1999). The goal of the realist researcher is, therefore, to identify the observable and non-observable social structures that originated the phenomena under investigation.
The interpretivism philosophical position is based on the idea that the social world is too complex to be described by laws. In this view, reality is considered as a social construct that depends on individuals’ perceptions implying that value-free data cannot be obtained to conduct research within the positivism tradition (Walsham, 1995; and Kelliher, 2005). According to the interpretivism philosophical position, a better understanding of the complex world can be achieved by considering lived experience from the point of view of those who live it. This is why the role of the interpretivist researcher is to enter the world of the subject under consideration and to understand this world from his/her own point of view (Saunders et al., 2009).

Finally, the pragmatism philosophical position argues that the most important determinant of the philosophical approach that researchers adopt is the research question. Moreover, if no particular philosophical position is more appropriate to answer the research question, then researchers can adopt variations in their epistemology and ontology. Consequently, the pragmatism allows researchers to work with a mix of methodologies (e.g. qualitative and quantitative) depending on the nature of the investigation.

Regarding the investigation developed in this thesis, the positivism philosophical position was adopted given the scientific nature of the research. This is because the investigation was based on a novel theory (i.e. the MEFT) that predicts the existence of a negative relationship between expected gross margin and business risk (i.e. the EPL) arising when farmers face heterogeneous market and resource restrictions. Moreover, the MEFT predicts that deviations around this line are explained by the incidence of non-economic drives affecting farmers’ strategic behaviour. Because all these predictions imply causal relationships that can be tested using statistical analysis, it was
found that the positivism philosophical position was the most appropriate approach to conduct the research.

The other philosophical approaches were not appropriate for the current investigation for the following reasons. Firstly, the aim of the realism philosophical position is to identify the reality (i.e. social structures) that explains the manifestation of a phenomenon which, in the context of this research, corresponds to crop allocations chosen by the ESBF. However, the aim of this thesis was not to identify an assumed underlying reality, but to test a theoretical development that explains farmers’ cropping decisions. Secondly, the aim of the interpretivism philosophical position is to gain a better understanding of the complex world by studying lived experience from the point of view of those who live it. In this case researchers have to enter the world of the subjects under consideration in order to understand this world from their own points of view. However, the current investigation considers a novel theory that is based on mathematical-economic principles and not on individuals’ points of view. As a consequence, this theory cannot be tested using information collected from the interpretivism philosophical position. Finally, it was concluded from the pragmatism philosophical position that the positivist research approach was the most appropriate approach for this thesis. This is because answers to the research questions defined in the current investigation can be obtained from the results of the statistical analysis. For example, if the statistical-econometric test validates the existence of the EPL, then it can be inferred that differences of crop allocations chosen by the ESBF are explained by the fact that these individuals faced different market and material resource barriers. This, in turn, offers an answer to one of the research questions of this investigation: Which variables/factors influenced farmers’ cropping strategic decisions?
5.1.2 Research Approach

The second layer presented in the research process shown in Figure 5.1 is the research approach. According to this figure, there are two research approaches: deductive; and inductive.

The deductive approach involves both the development of a theory and the deduction of hypotheses from it that are rigorously tested. That is, its aim is to validate or reject theoretical causal relationships between variables by testing these hypotheses. The data that is collected for this purpose is quantitative in nature. The inductive approach, in contrast, is based on interviews conducted with the purpose of collecting data that is normally qualitative in nature. The analysis of this data is then used to develop a theory (Saunders et al., 2009).

This thesis adopted the deductive approach because the current investigation was based on a novel theory (i.e. the MEFT) that was developed with the purpose of explaining farmers’ cropping decisions when they face different market and material resource restrictions. It was found that this approach was more appropriate because a number of testable hypotheses were deduced from the MEFT.

5.1.3 Research Strategy

The third layer presented in the research process shown in Figure 5.1 is the research strategy. According to this figure, there are seven research strategies (Maylor and Blackmon, 2005; and Saunders et al., 2009): (i) experiment (i.e. the study of casual links by determining whether a change in one independent variable causes a change in
the dependent variable); (ii) survey (i.e. strategy used to collect data from a sample of the population by using a questionnaire); (iii) case study (i.e. the use of multiple source of evidence to conduct empirical investigation of a contemporary phenomenon within its real life context); (iv) action research (i.e. a research in which the researcher is involved in making a change in the organisation by participating and observing the outcomes); (v) grounded theory (i.e. a strategy used to develop and build theory based on data analysis); (vi) ethnography (i.e. a strategy that is concerned with the study of culture using an inductive approach); and (vii) archival research (i.e. strategy that uses documents and administrative records as the main sources of data).

This thesis adopted the survey strategy. The reason is because when the research questions cannot be answered with existing data, a survey should be considered to collect relevant data (Maylor and Blackmon, 2005). Lack of data was due to the fact that some relevant statistics needed to test the hypotheses established in the research are not available in the public domain. It is for this reason that two particular forms of survey were considered in the present research: a semi-structured interview (i.e. interview where the researcher asks someone questions directly); and a questionnaire (i.e. technique in which people are asked to record their answers to a series of questions on paper).

In the pilot investigation developed in the current investigation semi-structured interviews were conducted with the objective of designing a questionnaire to be used for the collection of quantitative data. The questionnaire was pre-tested with ten farmers and re-designed in order to insert additional variables that were indicated as important by these individuals.
5.1.4 Method Choices

The fourth layer presented in the research process shown in Figure 5.1 corresponds to the method choices. According to this figure, they are: (i) mono methods (i.e. methods that consider a single data collection technique with a corresponding analysis procedure); (ii) mixed methods (i.e. methods that considers both qualitative and quantitative data collection techniques); and (iii) multi-methods (i.e. methods that consider either more than one qualitative collection techniques or more than one quantitative collection techniques, but not both).

This thesis adopted a multi-method choice that consisted of two different quantitative collection techniques: a questionnaire (a formal description of the questionnaire adopted in the research is presented below); and data collection from the public domain (e.g. Department for Environment Food and Rural Affairs and Agro Business Consultants). The reason for using a questionnaire is because only a fraction of the information that was needed to test the hypotheses established in the research was available in the public domain. The unavailable information was collected using the questionnaire.

5.1.5 Time Horizons

The fifth layer presented in the research process shown in Figure 5.1 corresponds to time horizons. According to this figure, they correspond to cross-sectional (i.e. the study of a phenomenon in a particular point in time) and longitudinal (i.e. the study of a phenomenon over a period of time).
The current investigation adopted a cross-sectional time horizon because the research project was subject to a time constraint. This is why the farmers in the sample were asked to fill the questionnaire only once during the period of the survey.

5.1.6 Techniques and Procedures

The last component of the research process scheme shown in Figure 5.1 corresponds to techniques and procedures used for data collection and data analysis.

As described above, the data collection techniques adopted in this research corresponded to a questionnaire and data collection from the public domain. On the other hand, the quantitative data collected from these techniques were analysed using statistic and econometric packages. The reason is because one of the aims of the investigation was test hypotheses that were deducted from MEFT proposed in this thesis. Because these hypotheses reflected causal relationships between variables, statistical analysis based on quantitative data was needed to test the validity of these hypotheses. Three packages were used to analyse the data collected and to test the relevant hypotheses: Excel 2003; SPSS 16 which was used to carry out a multivariate analysis and to develop descriptive statistic indicators; and Econometric View (EVIEWS) 6.0 which was used to undertake regression analysis. Finally, the results obtained from these packages were used to validate or reject the theory developed in the current research.
5.1.7 Schematic Representation of the Research Process

The research steps adopted in the research process considered in this thesis is summarised in Figure 5.2.

According to this figure, the research process starts with a theoretical development (or theory). As discussed in Chapters Three and Four, this development includes different...
approaches (some of them presenting overlaps) to explain farmers’ cropping decisions.
This theory postulates that farmers not only consider economic variables when making these decisions, but also non-economic drivers. This theoretical development was used as the basis for a conceptual framework which offers a more holistic approach to study the way in which farmers make cropping decisions. This conceptual model was used to infer theoretical behavioural patterns in terms of the levels of expected gross margin and business risk that they would achieve when forming their portfolio of crops. These behavioural patterns, in turn, were formalised as a number of hypotheses that constitute the hypotheses of the present research. In order to obtain relevant data to test these hypotheses, a questionnaire was used and was designed following the literature review and the results of a pilot investigation. The pilot investigation was subdivided in two stages. In the first stage, semi-structured interviews were carried out with the purpose of gaining an initial understanding of the way in which the ESBF adjusted to the SRR. This information was used to develop a draft of the questionnaire. In the second stage of the pilot investigation, on the other hand, the questionnaire was pre-tested with ten ESBF. Based on the results of the pilot analysis, the sample frame was defined and was used to select the sample used in the investigation. The results of the pilot investigation were also used to re-design the questionnaire and to obtain a final version. The final version of the questionnaire was administered to the ESBF in the sample. The data collected was analysed using Excel, SPSS and EVIEWS. This analysis comprised two stages of the research that are referred to as the static and dynamic stages of the research. Finally, the analysis of the results obtained in these stages of the research was used to validate or reject the theory proposed in the current investigation leading to a number of conclusions that are considered in the last step of the research strategy.
5.2 Common Methods Variance and Common Methods Biases

Before describing the methodology adopted in the research, it is important to point out that any methodology used in empirical works can be biased as a consequence of common methods variance (CMV). This concept is defined by Doty and Glick (1998) as the “systematic error variance that is related to the measurement approach rather than to the constructs of interest” (p. 376). That is, CMV reflects the systematic variance associated with the methods rather than the systematic variance associated with the traits. The main consequence of this systematic error variance is that it can cause spurious relationships between variables. This sort of bias is referred to as common method bias (CMB).

According to Podsakoff et al. (2003), there are a number of potential sources of CMB and these can be classified in four groups: (i) method effects produced by a common source or rater (i.e. self-report bias arising from the fact that the respondent providing the measure of the dependent and independent variables is the same person); (ii) method effects produced by item characteristics (i.e. bias arising from the manner in which items are presented to respondents); (iii) method effects produced by item context (i.e. bias arising from the subjective interpretation that an individual might attribute to an item when it is placed in a particular context with respect to the other items included in a questionnaire); and (iv) method effects produced by measurement context (i.e. bias arising from the contextual influence in which the measures are obtained such as time, location and medium used to obtain measurement).

Given the nature of the current research, these types of sources of CMB could potentially introduce biases in the relationships defined in the investigation. To illustrate
this, let us consider the types of variables that are needed in order to test the hypotheses established in the research in the context of the proposed multivariate model (see Figure 4.2). These variables are: (1) economic variables (gross margin and variance of gross margin of the portfolio of crops chosen by the ESBF); (2) demographic and factual data (age, sex, type of education, location, etc); (3) variables associated with market and material resources constraints; (4) variables representing drivers of dynamic capabilities; (5) variables associated with farmers’ goals; and (6) variables associated with social-psychological drivers (i.e. attitudes, subjective norms, and perceived behavioural control).

Regarding method effects produced by a common source or rater, it has been argued that individuals tend to try to maintain consistency in their responses to similar questions associated with their attitudes, perceptions and behaviours. For example, Kline et al. (2000) argued that a person who reports high levels of stress in their job might also report low levels of job satisfaction due to the incidence of a third common variable. This would, therefore, cause a spurious relationship. According to Podsakoff and Organ (1986), this is one of the principal sources of biases and is presented, in particular, when the dependent and independent variables are all associated with attitudes, perceptions and behaviours (i.e. the variables of groups 5 and 6 described above). This, however, is not a problem for the current investigation because the dependent variable is an economic variable (i.e. a variable of group 1). To see that, notice that the current investigation is based on the efficient portfolio line (EPL) inferred in Section 4.3.1. One of the key assumptions of the proposed multivariate model is that any deviation from this line is caused by variables other than business risk such as farmers’ goals, attitudes, subjective norms, and perceived behavioural control, among others. In other words, it is assumed that the levels of the dependent variable,
which is an economic variable (i.e. expected gross margin), is influenced by non-economic drivers. As a consequence, the problem identified by Podsakoff and Organ (1986) is not presented in the current investigation.

Nonetheless, there are other potential sources of bias that could influence the results of the research. They correspond to implicit theories, social desirability, acquiescence, and transient mood states. They are explained in the context of the current investigation as follows. According to Phillips and Lord (1986), human observers have enduring beliefs and implicit theories concerning the covariances among traits and behaviours. If these theories do not represent reality, then they can introduce CMB in the research. In the case of the ESBF, these individuals could have implicit theories that relate expected gross margin (i.e. the dependent variable) with some non-economic drivers such as feeling pride of ownership or enjoyment of work tasks among others. Thus, for example, if a farmer has an implicit theory that relates high economic performance with pride in ownership, and if this individual feels pride in ownership, then this individual could eventually report higher levels of gross margin than the levels that she/he really achieved. In order to minimise this source of bias, a recommendation provided by Podsakoff et al. (2003) was adopted. This consists of obtaining measures of the dependent and independent variables from different sources. Information related to independent variables was obtained from the farmers in the sample used in the investigation. For the dependent variable, in contrast, farmers were asked to report only the proportion of land that they assigned to the crops they produced after the closure of the ASBF. However, the information needed to calculate the expected gross margin of their portfolios of crops was obtained from the Agricultural Budgeting & Costing Book (see Agro Business Consultants in the references) which is available in the public domain.
Another potential source of bias is social desirability, which is defined by Ganster et al. (1983) as the “tendency for an individual to present him or herself, in test-taking situations, in a way that makes the person look positive with regard to culturally derived norms and standards” (p. 322). In the case of the ESBF, social desirability can affect the relationship between expected gross margin and non-economic drivers that could be associated with social approval and acceptance such as maintaining nature and environmental value. In order to minimise this source of bias, it was explained to the farmers that there were no right or wrong answers and that their anonymity would be protected. These strategies are formally recommended by Podsakoff et al. (2003).

With respect to acquiescence, this concept is defined by Winkler et al. (1982) as the “tendency to agree with attitudes statements regardless of content” (p. 555). This is a problem because it increases the correlation among items that are worded similarly even when they are not conceptually linked. In the context of the current investigation, this could cause multicollinearity in the regression because acquiescence can generate correlations among the explicative variables. While multicollinearity does not reduce the predictive power of a regression model as a whole (Dougherty, 2007), it makes the interpretation of the effects of individual variables difficult, as only some of them are truly related to the dependent variable. In order to partially reduce acquiescence from the investigation, items that belonged to different approaches considered by the proposed multivariate model were presented in different sections of the questionnaire. For example, Section Four of the questionnaire only included statements related to farmers’ goals (see Appendix L).
Finally, transient mood state corresponds to the artifactual covariance in self-report measures caused by a particular mood of the respondent (Podsakoff et al., 2003). Unfortunately it was not possible to minimise this source of bias because farmers’ mood was not a control variable in the context of the current research.

Regarding method effects produced by item characteristics, researchers have identified item complexity and ambiguity as a source of CMB because this requires respondents to develop their own idiosyncratic meaning of these items. For example, Peterson (2000) argued that this problem can arise from the use of words with multiple meanings or words that are unfamiliar or infrequently used. In order to reduce this source of bias, the present research adopted items that have successfully been used in related works to explain farmers’ strategic behaviour. In particular, the present investigation extended the research developed by Bergevoet et al. (2004) and Willock et al. (1999). Because these academic works have been used to study farmers’ behaviour, they employed words that are normally used in agriculture.

Scale format and scale anchors have also been identified as potential sources of CMB. In particular it has been argued that similar scale formats (e.g. Likert scales) and similar scale anchors can increase the covariance observed among the constructs investigated as a result of the consistency in the scale properties rather than the content of the items (Podsakoff et al., 2003). This is not a problem in the current research because the scale used to measure the dependent variable is different from the scale adopted to measure the independent variables. The former is based on gross margin statistics of different crops obtained from the Agricultural Budgeting & Costing Book. In contrast, independent variables were measured using a Likert scale for statements, and discrete
and categorical scales for demographic and factual data (age, sex, type of education, location, etc).

Regarding method effects produced by item context, there are some sources of CMB in this group that could eventually bias the current investigation. For example, it has been argued that some aspects of a particular item can appear more salient when related items have been asked previously (Salancik, 1984). In order to minimise this source of bias, items related to farmers’ goals, attitudes toward farming, subjective norms and perceived behavioural control were presented without following a defined contextual pattern. This strategy is, however, imperfect because alternative ways of ordering the items included in the questionnaire could probably involve alternative contexts that could be linked with other priming effects. As a consequence, it was not possible to fully eliminate this type of bias.

Another potential source of bias is the scale length. According to Hinkin (1995), it is important that the scale used in a questionnaire generates sufficient variance among the respondents in order to conduct statistical analysis. However, scales that are too long can introduce biases that arise as a consequence of respondent fatigue and carelessness. This suggests that there exists an optimal scale length. This has indeed been identified by some researchers. For example, Lissitz and Green (1975) determined the optimal number of scale points of a Likert rating scale using a Monte Carlo approach. They found that five points was the optimal number because the reliability of the scale decreased after this point. In fact, they rejected the seven scale point as an optimal number. A similar result was found by Hinkin (1995). Considering these academic works, the current research adopted a five-point Likert scale for variables that represent statements.
Finally, regarding method effects produced by measurement context, there are two sources of CMB that could introduce biases in the current investigation. One of them corresponds to time and location of measurements. According to Podsakoff et al. (2003), measures that are taken at the same time and place can share systematic covariation. This is because using the same time and place provides a context in which relationships between variables can co-exist as a consequence of short-run memory, and in which the use of implicit theories are facilitated. Unfortunately it was not possible to reduce this source of CMB because the project was subject to a time constraint. This was due to the fact that the farmers in the sample were only willing to participate in some particular periods of the year when they were not too busy (i.e. after sow and harvest).

The other potential source of bias relating to measurement context is, the medium used to obtain measurement. For example, Richman et al. (1999) found that face-to-face interviews produce lower accuracy than paper and pencil questionnaires. In order to minimise this source of bias, the present investigation was based on a paper and pencil questionnaire.

It is important to clarify that even when efforts were made to minimise most of the potential sources of CMB in the current research, they were not fully eliminated. As a consequence, the results obtained in this research have to be considered with caution. Nonetheless, the methodology adopted in the investigation was considered as the best choice, given the number of constraints (e.g. time, location and budget constraints) faced in the investigation. This methodology is explained in detail in the next section.
5.3 Methods used in the Research

This section explains in detail the methods adopted in the current research.

5.3.1 Method used in the pilot investigation

Following the suggestion of Maylor and Blackmon (2005), a pilot investigation was carried out with the purpose of facilitating the development of indicators that would form the questionnaire to be used in the present research. The method for the pilot analysis was based on two stages. The first one consisted of interviewing some relevant agents using semi-structured questions with the objective of gaining an initial understanding of the way in which the ESBF adjusted to the closure of the ASBF. These agents were four farmers; Mr. Andrew Richards who used to be the head of the National Farmers Union (NFU) located in Telford at the time of the interview; and Mr David Allison who is the dealer who used to work in the ASBF before the closure. The information collected in this stage and the antecedents obtained from the literature were both used to design a draft of the questionnaire used in the research. In the second stage of the pilot investigation the draft of the questionnaire was pre-tested with ten ESBF.

5.3.2 Method used in Questionnaire Design

In order to test the hypotheses established for the research and to test the existence of relationships between variables, closed questions were adopted because they are expressed in numerical standardised scales. Most of these questions were extracted and adapted from closely related existing surveys conducted by researchers studying...
farmers’ strategic behaviour (see Bergevoet et al., 2004; and Willock et al., 1999). The questions were grouped in six sections with the purpose of including the approaches that were considered in the proposed multivariate model (see Figure 4.2) and also demographic and factual data.

The first section connected demographic and factual data on age, level of education, agricultural training, farming size, number of hectares used with sugar beet before the closure of the ASBF, and geographical location. The second section was designed to collect data on the crop allocations chosen by the farmers in the sample in year 2008 and to identify the type of market where they were operating. Section three contained statements on barriers that prevent farmers from choosing crops with high gross margin while section four contained a list of statements on farmers’ goals. Section five contained a list of statements on attitudes toward farming, perceived behavioural control and subjective norms. Finally, section six contained a list of statements on attitudes toward different business strategies. A five point Likert scale was used for questions regarding statements. The questionnaire was pre-tested in the pilot study with ten ex-sugar beet farmers. The questionnaire is shown in Appendix L.

While the questionnaire was useful to collect the information needed to test the hypotheses established for the research, it had some limitations that are described as follows. Firstly, the number of statements on market barriers; farmers’ goals; attitudes toward farming; perceived behavioural control; subjective norms; and attitudes toward different business strategies considered in the questionnaire is large. Answering this large number of statements could have caused fatigue to the respondents negatively affecting the reliability of the survey. Secondly, some questions such as Questions 9 and 10 (see Appendix L) required the participants to use their knowledge to relate
determined variables in some contexts that they were not necessarily familiar with. As a result, answering these questions could have been considered as a difficult task for these individuals. This is because the participants had to make judgments under uncertainty with the objective identifying opportunities which demands levels of informational processing (Keh et al., 2002). Therefore, the participants could have answered their questions with lack of accuracy in order to avoid the associated costly informational processing. After all, they were facing hypothetical unknown contexts but not real ones. As a result, answering questions with lack of accuracy would not have affected their business performance in the real world.

Because these limitations could potentially have affected the reliability of the answers provided by the farmers, the results obtained from the information collected from the questionnaire have to be considered with caution.

5.3.3 Sampling method

One of the most difficult tasks of this investigation was to obtain a suitable sample to test the hypotheses establishes in the research. Unfortunately a number of obstacles prevented the author of this thesis from finding a simple random sampling strategy. As a consequence, only a small sample was obtained from an alternative sampling strategy. Regrettably, this second best strategy increased the probability of introducing some specific types of bias. While efforts were made to minimise this problem (see the discussion below), bias was not fully eliminated. The types of bias that could have affected the results obtained in this research correspond to: (i) non-response bias; and (ii) bias associated with small sample size.
The objective of this section is to describe the sampling strategy adopted in this research and the associated sources of bias listed above. For this purpose, the section was subdivided in three subsections. Subsection 5.4.3.1 describes the sampling strategy adopted in the research. Section 5.4.3.2 explains the consequences of working with the small sample obtained from the sampling strategy. Finally, Section 5.4.3.3 highlights some of the key points discussed in the previous sections.

5.3.3.1 Sampling Strategy

Initially, the objective was to obtain a random sample from the population of ESBF. Because the number of these farmers in 2005 (i.e. the year before the closure of the ASBF) was 592 (Department for Environment Food and Rural Affairs, 2010b), the target was to obtain a response rate of at least 20% in order to obtain a sample composed of no less than 118 farmers. In order to complete with this objective, a list of ESBF was needed. Unfortunately this information is not available in the public domain.

Different unsuccessful attempts to obtain a list of ESBF were made. The first attempt was to send a letter to the British Sugar Corporation asking for a list. However, the corporation did not reply. A copy of this letter is presented in Appendix M. A second attempt was to approach the British Sugar Corporation by email asking for the list of ESBF. As no reply was forthcoming, it was decided to look for other sources. One possible source was the NFU located in Telford. The head of the NFU Mr. Andrew Richards explained that some members of the union were sugar beet growers. However, he did not have a list of these individuals. Even though, Mr. Richards sent an extensive invitation to the members to participate in the project by means of the NFU newsletter. A copy of this invitation is presented in Appendix N. Unfortunately no farmer
responded the invitation. In other words, the response rate was zero. Finally, the cost of sending an invitation to all the farmers of the West Midlands Region was estimated. Since the number of farmer holdings in this region is approximately 27,200 (Department for Environment Food and Rural Affairs, 2010b), it was found that the cost of this strategy was prohibitively high given the budget of the project.

The poor response to the letters presented in Appendices M and N revealed two facts that prevented the author of this thesis from finding an appropriate random sample to test the hypothesis established in the research. Firstly, the list of ESBF is private information and institutions that have this list are not willing to share this information. Secondly, ESBF who were members of the NFU were not willing to participate in the research and this was reflected as a zero response rate from these farmers. As discovered latter (see the discussion on snowball technique below), the most important factor explaining this lack of interest was time constraint faced by the ESBF. That is, they had only few available weeks during the year to participate in the survey. This is because most of the time they were involved in productive and time demanding tasks such as harvesting crops.

Because the two facts described above prevented the author of this thesis from obtaining a random sample, an alternative sampling strategy was adopted. This strategy was considered as the second best given the time and budget constraints of the project and was based on a combination of the following sampling techniques: (i) cluster sampling; (ii) stratified sampling; and (iii) snowball sampling. These techniques were selected with the purpose of reducing lack of representativeness when possible and are explained as follows.
The sample cluster was selected using a similar approach to that adopted by the Rural Business Unit of the University of Cambridge and The Royal Agricultural College (2004). This approach consisted of determining the proportions of sugar beet holdings in the most relevant counties of the West Midlands region before the closure of the ASBF. After that, relatively similar proportions of farmers were included in the sample. For this purpose, the year 2005 was selected to estimate the regional proportions of sugar beet holdings because this was the last year in which the ASBF was operating. As a consequence, this year provided the most recent picture of the distribution of ESBF in the region when the SRR was implemented. The following table shows the proportions of sugar beet holdings in the most relevant counties of the West Midlands region in year 2005, and the proportion of farmers that were included in the sample:

<table>
<thead>
<tr>
<th>Counties and surrounding areas</th>
<th>Proportion in the West Midland in year 2005 (%)</th>
<th>Proportion of farmers included in the sample (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shropshire</td>
<td>48</td>
<td>46</td>
</tr>
<tr>
<td>Worcestershire</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Herefordshire</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Staffordshire</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>surrounding areas</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

The sample stratification was made considering the size of the farm in terms of the number of hectares. It was not possible to find official statistics on this variable. Nonetheless, a criterion was established based on the opinions of the ten farmers that formed the pilot sample. The precaution was taken to include a balanced number of farmers to the classes defined by this measure. Table 5.2 shows the sample distribution for each county based on this criterion.
Table 5.2 Sample Distribution of Farm Sizes for each County

<table>
<thead>
<tr>
<th>COUNTY</th>
<th>Small $\leq 200$ ha</th>
<th>Medium $200 &lt; 600$ ha</th>
<th>Large $\geq 600$ ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shropshire</td>
<td>30</td>
<td>52</td>
<td>18</td>
</tr>
<tr>
<td>Worcestershire</td>
<td>37</td>
<td>50</td>
<td>13</td>
</tr>
<tr>
<td>Herefordshire</td>
<td>17</td>
<td>66</td>
<td>17</td>
</tr>
<tr>
<td>Staffordshire</td>
<td>0</td>
<td>83</td>
<td>17</td>
</tr>
<tr>
<td>Rest</td>
<td>40</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Whole sample</td>
<td>27</td>
<td>56</td>
<td>17</td>
</tr>
</tbody>
</table>

According to Salganik and Douglas (2004), the snowball technique consists of selecting respondents from the friendship network of existing members of the sample. The sample process starts when the researcher selects an initial small number of respondents referred to as seeds. After that, the seeds recruit others to participate in the study, and this process of existing sample members recruiting future respondent members continues until the size of the sample selected for the investigation is reached. The snowball technique adopted in the current research used one seed farmer for each relevant county of the West Midlands region. Using this approach, it was possible to find a number of ESBF that was consistent with the sample cluster strategy defined above.

The survey strategy adopted in this research was useful to find a sample of ESBF. However, this strategy could potentially have introduced a source of bias referred to as non-response bias. According to Dattalo (2008), this bias arises when respondents and non-respondents differ on variables of interest making it difficult to extrapolate conclusions obtained from respondents to non-respondents. Because one of the strategies used to obtain the sample was the adoption of a snowball technique, it is
possible that the farmers who agreed to participate in the project were friends or like-minded people in the network. Consequently, extrapolating conclusions from this sample to explain cropping strategic behaviour of farmers who did not participate in the investigation could be biased. This is an important drawback of this research and has to be kept in mind when discussing the results obtained in the empirical part of the research.

5.3.3.2 Sample size

The sample strategy adopted in this thesis was useful to overcome the problems of low response rate and lack of a list of ESBF described above. However, the sample obtained from this method was small and consisted of 48 farmers. According to Department for Environment Food and Rural Affairs (2010b) statistics, the number of sugar beet growers in the West Midlands region in 2005 was 592. This implies that the sample used in the research which corresponds to 8.1 per cent of this total, and this sample was collected over a period of six months. The reason of why it was not possible to obtain a larger sample is because the project had cost and time constraints that limited the possibility of using more resources to expand the size of the sample. Apparently, this is not an uncommon problem. According to Bryman and Bell (2003), time and cost are the main factors that prevent researchers from obtaining larger samples.

The main disadvantage of working with small samples is that the results obtained from these samples could be biased. To see that, consider the following discussion. An important concept associated with sample size is sampling error and is defined by Maylor and Blackmon (2005) as the “difference between the sample you select and the
population you take it from” (p. 198). That is, it is the error of taking too many elements of one type and not enough elements of another type.

According to Dattalo (2008), sampling error decreases when the size of the sample increases. This is because the probability of representing the population (i.e. the precision of the sample) increases when researches use large sample. This is captured as a decrease in the 95% confidence interval of the parameter that is estimated from the sample. To see that, consider the following 95% confidence interval definition for the population mean $\mu$ (Upton and Cook, 1996):

$$
\left[ \bar{x} - 1.96 \frac{s}{\sqrt{n}}, \bar{x} + 1.96 \frac{s}{\sqrt{n}} \right],
$$

where $\bar{x}$ is the sample mean; $s$ is the standard deviation of the sample; and $n$ is the size of the sample. Suppose that a researcher wants to determinate whether a population consumes 2.5 kilos of apples per week on average. That is, this researcher wants to test the null hypothesis $H_0: \mu = 2.5$. Suppose that this individual selects a sample of size $n = 40$ to test this hypothesis. Assume that the standard deviation of the sample is equal to 2 (i.e. $s = 2$) and the sample mean is 3 (i.e. $\bar{x} = 3$). Using this information and the expression of the confidence interval described above, the 95% confidence interval for the population mean becomes

$$
\left\{ 3 - 1.96 \frac{2}{\sqrt{40}}, 3 + 1.96 \frac{2}{\sqrt{40}} \right\} = (2.4; 3.6). 
$$

Because $\mu = 2.5$ belongs to this interval, the researcher concludes that the null hypothesis is accepted at the 5% of significant level (or 95% of confidence). Suppose now that another researcher replicates the experiment but using a sample of size $n = 200$. Suppose in addition that this sample has the sample mean and the same standard deviation than the small sample (i.e. $\bar{x} = 3$ and $s = 2$). Using this information, the 95% confidence interval for the
population mean becomes \( \left( 3 - 1.96 \frac{2}{\sqrt{200}}, \bar{x} + 1.96 \frac{2}{\sqrt{200}} \right) = (2.7; 3.3) \). Because in this case the population mean \( \mu = 2.5 \) does not belong to this interval, the researcher concludes that the null hypothesis is rejected at the 5% of significant level.

It is clear from this example that the 95% confidence interval increases when the size of the sample decreases. The main implication of this change is that it is more difficult to reject the null hypothesis when the sample is small leading to results that could not represent the population. In the example, the null hypothesis was not rejected when using a sample of size 40, but it was rejected when using a sample of size 200. This means that in this example the small sample led to a biased result. This is the type of bias that could potentially have affected the results obtained in the empirical part of this thesis. As a consequence, the conclusions obtained from these results have to be considered with caution.

5.3.3.3 Final Comments

As discussed in the previous sections, there are two types of bias that could potentially have affected the results obtained from the sample used in this investigation. The first one corresponds to non-response bias; and the second one is bias associated with the small sample used in the research.

Regarding the non-response bias, it is important to emphasise that this bias could have been introduced from the snow ball technique adopted in this research. This is because in this technique farmers suggest friends meaning that individuals in the sample could
be like minded. As a consequence, the results could reflect the behaviour of a liked
minded fraction of ESBF rather than the behaviour of the population.

Regarding small samples, on the other hand, it is discussed above that inference
obtained from these samples could be biased because sampling error is normally larger
when samples are small. This is because confidence intervals of parameters under study
are wider making it more difficult to reject null hypotheses that in reality are false. It is
interesting to notice, however, that apparently the difficulty of getting data from primary
sources in agriculture has also prevented other researchers from using large and random
samples in their studies. For example, Kobrich et al. (2003), Milan et al. (2003),
Valeeva et al. (2005), and Morgan-Davis et al. (2009) used samples of 67, 52, 52 and
20 farmers, respectively. Given the difficulty of gathering data from primary sources,
the small population of ESBF, and the limited budget supporting the present research,
the sample used in this study is considered as appropriate in this context. Nonetheless,
the results have to be considered with caution and within the context of the sample
because non-response bias and bias associated with the small sample could potentially
have affected the results obtained in the present investigation.

5.3.4 Methods adopted in the Static Stage of the Research

The research was subdivided in two stages. The first one, called the static stage, studied
the economic and non-economic drivers that explain the cropping choice made by the
ESBF after the closure of the ASBF. This stage was called static because it described
the determinants of cropping decisions in a particular point in time. The second stage,
called the dynamic or experimental stage, studied how the ESBF would behave in a
hypothetical situation in which these individuals were given all the material resources
needed to develop dynamic capabilities. This stage was called dynamic because it compared the cropping decisions made by the ESBF in the static stage with the cropping decisions that these farmers would have made in the hypothetical situation.

This section describes in particular the methodology adopted in the static stage of the research. This stage was subdivided in three phases which are explained as follows.

5.3.4.1 Methodology used in Phase I of the static stage of the research

The objective of Phase I was to provide a general overview of the main characteristics of the ESBS in the sample. Given the descriptive nature of this phase, mainly descriptive statistic indicators (i.e. average and standard deviation) were employed. Only one linear regression model was estimated with the purpose of determining whether farm size was related to the number of farm workers.

5.3.4.2 Methodology used in Phase II of static stage of the research

As discussed in Section 3.2.2, one of the reasons that could explain why the ESBF did not choose crops with high levels of gross margin to replace sugar beet was that they were unable to develop dynamic capabilities. The objective of Phase II was to determine whether this argument holds. In order to complete this objective, the drivers of dynamic capability identified in Section 3.2.2 in conjunction with descriptive and inferential statistics were used to determine whether the ESBF would develop dynamic capabilities. The results were used to complement the behavioural analysis developed in the static stage of the research.
5.3.4.3 Methodology used in Phase III of the Static Stage of the Research

The objective of Phase III of the research was to determine the economic and non-economic drivers that explained the crop allocations chosen by the ESBF after they adapted to the implementation of the SRR. The resulting framework was considered as the benchmark model for the experimental analysis developed in the second stage of the research. The methodology used in Phase III is described as follows.

a) Expected value and variance of the gross margin of the portfolio

The theoretical development presented in Chapter Four used a graphical strategy to identify behavioral cropping patterns under different scenarios. The graph used for this purpose considers two variables: (i) the expected value of the gross margin of the portfolio of crops which is presented in the vertical axis; and (ii) the variance of the gross margin of this portfolio which is presented in the horizontal axis. These variables are associated with two basic objectives that farmers could consider when forming portfolio of crops: maximising the expected gross margin of the portfolio, and minimising the associated business risk (this concept is defined at the beginning of this Chapter and also in Footnote 1 in Chapter One).

Obtaining a measure of these variables is crucial for the estimation of the EPL which is one of the most relevant theoretical developments of this thesis11. As discussed in

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11 A formal discussion of how this line is generated is presented in Section 4.3.1 and in particular in Subsection 4.3.1.3. A formal mathematical derivation of this line is presented in Appendix H.
Sections 4.3.2 and 4.3.3, this is because this line constitutes a benchmark that was used to identify behavioural deviations that are explained by the incidence of non-economic drivers and differences in the capacity to create dynamic capabilities.

The objective of this subsection is to explain how these variables were obtained. Before explaining the technical approach used to obtain these variables, however, it is important to explain the rationale associated with them.

The expected gross margin is used because farmers cannot anticipate with certainty the level of gross margin that they will obtain when forming portfolio of crops. As explained at the beginning of the present chapter, this is because farmers face a number of uncertainties that can affect the level of gross margin obtained after harvesting and selling their production. They correspond to weather uncertainty which affects physical production of crops, market uncertainty arising from the unpredictable nature of output prices, institutional risk arising from unpredictable changes of rules affecting production, and personal risk arising from unpredictable events such as illness. Because farmers cannot anticipate these uncertainties, it is normally assumed that these individuals consider the average of the levels of gross margin obtained in the past as an imperfect indicator of the gross margin that they will obtain in the next year after selling the crops that compose their portfolios. A farmer who considers the average of the levels of gross margin obtained in the past to predict future levels of this variable is said to have adaptive expectations (Hardaker et al. 1998).

Regarding business risk, on the other hand, a common indicator of this variable is the variance of the gross margin obtained over a determined period of time. As explained in Footnote 2 in Chapter Two, this indicator is used to reflect the aggregate effect of all the
uncertainty influencing the levels of gross margin made by a farm which is in essence the definition of business risk (see Footnote 1 in Chapter One). For example, gross margin can suffer important fluctuations in different years when the prices of some crops are too volatile. Consequently, the business risk associated with these crops is high, a fact that is reflected in the variance of the gross margin obtained from the production of these crops.

The following development formally shows how the expected gross margin and business risk of portfolio of crops were obtained in the current investigation. In order to obtain of expected gross margin, the ESBF in the sample were asked to report the crops that they produced in 2008 and the number of hectares that they assigned to each of these crops (see question 4 in Appendix L). Since the SRR was formally implemented on 20th February 2006, it was considered that 2008 was a reasonable year to investigate how farmers had adapted to this reform. The proportion of land allocated to each crop in that year was used as a weight to calculate the gross margin of the portfolio of crops chosen by the ESBF. Information of gross margin (£/ha) for single crops was obtained from the statistics of the Agricultural Budgeting & Costing Book (see Agro Business Consultants in the references). Some farmers in the sample rented a fraction of their land to other farmers for the production of potatoes. This renting activity was considered as a business activity that formed part of the portfolio of crops. The renting price was used as a measure of gross margin for this activity. This price was reported by the farmers and varied from £667/ha to £740/ha. It included both the renting price itself plus payments received for additional services such as the provision of machinery, among others. According to the farmers, this activity was free of risk. Let $w_{ik}$ be the proportion of land allocated to crop $i$ by farmer $k$ in 2008, let $\Omega(K)$ be the set of crops chosen by this farmer in that year, and let $\pi_{it}$ the gross margin of crop $i$ in period $t$. The
gross margin in year \( t \) of the portfolio chosen by farmer \( k \) in year 2008 \( (\pi_k) \) was, therefore:

\[
\pi_{kt} = \sum_{i \in \Omega(K)} w_{ik} \pi_{it} \tag{5.1}
\]

This expression was used to calculate the gross margin of the portfolio of crops in the years 2007, 2006, 2005, 2004 and 2003. In other words, \( \pi_{2007}, \pi_{2006}, \pi_{2005}, \pi_{2004} \) and \( \pi_{2003} \) were calculated for each farmer in the sample. This information was used to obtain the expected gross margin of the portfolio.

Since the portfolio of crops in year 2008 was actually chosen in year 2007, the way in which farmers formed their expectations of the gross margin of that portfolio had to be defined. For this purpose, it was assumed that the ESBF had adaptive expectations (for a formal description of this type of expectation, see Dougherty, 2007, Chapter 11). The following Koyck distribution version of the adaptive expectation model was adopted in order to calculate the gross margin of the portfolio chosen by farmer \( k \) expected in year 2008:

\[
E(\pi_{2008}) = \lambda \pi_{2007} + \lambda(1-\lambda)\pi_{2006} + \lambda(1-\lambda)^2\pi_{2005} + \lambda(1-\lambda)^3\pi_{2004} + \lambda(1-\lambda)^4E(\pi_{2003}) \tag{5.2}
\]

In the equation above, \( \lambda \) \((0 \leq \lambda \leq 1)\) is a parameter which represents the speed at which the expected value adjusts to actual outcomes: the larger the value of \( \lambda \), the quicker the adjustment speed. The advantage of using this distribution is that the unknown term \( E(\pi_{2003}) \) can be omitted under the assumption that \( \lambda \) lies between 0 and 1 because the factor \( \lambda(1-\lambda)^5 \) become very small. As a consequence, the variable \( E(\pi_{2003}) \) can be
calculated using only known variables. Finally, a grid search technique was used to obtain a specific value of $\lambda$ (Dougherty, 2007). This technique consists of assuming different values of $\lambda$ between 0 and 1 in Equation 5.2, and to use these values to run different regression estimations of a theoretical equation that assumes implicitly that individuals have adaptive expectations such as the EPL (see Section 4.3.1 and Appendix H). In other words, one regression is estimated for each assumed value of $\lambda$. Among these estimations, the one with the lowest residual sum of the squares is selected because this is, by definition, the least square solution. In the case of the current investigation, different values of $\lambda$ between 0 and 1 were assumed, and each of them was fitted in the regression used to estimate the EPL. The econometric analysis conducted in the current research revealed that $\lambda = 0.5$ was the value that produced the lowest residual sum of the squares.

In order to obtain the variance of the gross margin (square of £/ha) of the portfolio of crops chosen by farmer $k$ in year 2008, the variance of the gross margin of each single crop $i$ chosen by this farmer, $V(\pi_{ik})$, was calculated for the years 2007, 2006, 2005, 2004 and 2003. After that, the proportions of land allocated to each crop by farmer $k$ in 2008 were used as weights to calculate the variance of the portfolio chosen by this farmer, $V(\pi_k)$. As an example, suppose that farmer $k$ decided to establish crops $i$ and $j$ in 2008. Then the variance of this portfolio is defined by the following expression: $V(\pi_k) = w_{ik}^2V(\pi_{ik}) + w_{jk}^2V(\pi_{jk}) + 2w_{ik}w_{jk}COV(\pi_{ik}, \pi_{jk})$, where $COV(\pi_{ik}, \pi_{jk})$ is the covariance between $\pi_i$ and $\pi_j$ (see Upton and Cook, 1996). A more detailed explanation of how this variance is calculated based on a practical example is presented in Appendix O.
b) Statistical and econometric analysis.

The statistical and econometric analysis used in Phase III was organised in three steps (see Bergevoet et al., 2004):

Step 1: Testing the HRA and the HSCRA using an experimental method. In order to validate the multiple efficient frontiers theory, the HRA and the HSCRA were tested using an experimental method (i.e. a method designed to find out the preferences of farmers by asking them to choose among different alternatives. See Gomez-Limon et al., 2003). The experimental method consisted of estimating an econometric version of the utility function presented in Equation F.2 (see Appendix F). This expression and its econometric version are presented as follows:

\[
E(U(\pi)) = E(\pi) - r_oV(\pi)/2 \tag{5.3}
\]

\[
E(U(\pi)) = \beta_0 + \beta_1 E(\pi) + \beta_2 V(\pi) \tag{5.4}
\]

Where \(\beta_0, \beta_1,\) and \(\beta_2\) are the regression coefficients. To see how Equation 5.4 can be used to test the HRA, consider the following figure which shows graphically this equation for two farmers: a risk taker and a risk avoider.
Figure 5.3 Rationale of the Experimental Method: testing the HRA

Figure 5.3 (a) shows the case of a farmer who is a risk taker. This farmer is risk taker because his expected utility increases from $E(U(\pi))_0$ to $E(U(\pi))_1$ when business risk measured as the variance of the gross margin increases from $V(\pi)_0$ to $V(\pi)_1$. In other words, a risk taker farmer has an expected utility function with positive slope. Figure 5.3 (b), on the other hand, shows the case of a farmer who is a risk avoider because his expected utility decreases from $E(U(\pi))_0$ to $E(U(\pi))_1$ when business risk increases from $V(\pi)_0$ to $V(\pi)_1$. This implies that the expected utility function of this farmer has a negative slope. A possible way to capture risk aversion attitudes is, therefore, by determining the value of the slope of the utility function presented in Equation 5.4. That is, by determining the value of $\beta_2$. If $\beta_2 > 0$, then the farmer is risk taker. If $\beta_2 < 0$, then the farmer is risk avoider. Finally, if $\beta_2 = 0$, then this farmer is risk neutral.

In order to test the HSCRA, on the other hand, it is necessary to introduce a multiplicative dummy to the model presented in expression 5.4. To understand why, let us consider the following example. Suppose that farmer $i$ has a different attitude
towards risk with respect to a referential group of farmers. This implies that for this farmer the dummy variable is $D_i = 1$. In contrast, the dummy variable for any farmer $j \neq i$ is $D_j = 0$. This means that the utility function of any farmer $j \neq i$ and the utility function of farmer $i$ are, respectively:

$$E(U(\pi)) = \beta_0 + \beta_1 E(\pi) + \beta_2 V(\pi)$$

(5.5)

$$E(U(\pi)) = \beta_0 + \beta_1 E(\pi) + \beta_2 V(\pi) + \beta_i D_i V(\pi) = \beta_0 + \beta_1 E(\pi) + (\beta_2 + \beta_i) V(\pi)$$

(5.6)

The only difference between these expressions is given by the intercept of the variance of gross margin. For any farmer $j \neq i$ this intercept is $\beta_i$, and for farmer $i$ the intercept is $\beta_2 + \beta_i$. Therefore, since this intercept represents the coefficient of absolute risk aversion (see Equation 5.3), if $\beta_i$ is negative, then $\beta_2 > \beta_2 + \beta_i$ which implies that farmer $i$ is more risk averse than farmer $j$. Conversely, if $\beta_i$ is positive, then $\beta_2 < \beta_2 + \beta_i$ which implies that farmer $i$ is less risk averse than farmer $j$. Finally, if $\beta_i = 0$, which happens when the dummy variable assigned to farmer $i$ is not statistically significant, then $\beta_2 = \beta_2 + \beta_i$ which implies that farmer $i$ has the same attitude towards risk than farmer $j$. The following figure shows the case when $\beta_2 > \beta_2 + \beta_i$ when both farmers are risk adverse.
Variance of Gross Margin $V(\pi)$

$E(U(\pi)_i)$

Slope = $\beta_2$

$E(U(\pi)_j)$

Slope = $(\beta_2 + \beta_i)$

Variance of Gross Margin $V(\pi)$

Figure 5.4 Rationale of the Experimental Method: testing the HSCRA

This figure shows that both farmers are risk averse because their expected utility functions both have negative slopes. However, farmer $i$ is more risk averse than farmer $j$ because the expected utility function of the former, denoted as $E(U(\pi)_i)$, is steeper than the expected utility function of the latter, denoted as $E(U(\pi)_j)$.

As explained in the previous paragraphs, Equation 5.4 can be used to test both the HRA and the HSCRA. For this purpose, it is necessary to have data on three variables: (i) the expected utility of each farmer, $E(U(\pi))$; (ii) the expected gross margin of different crop alternatives, $E(\pi)$; and (iii) the level of risk of each of these alternatives, $V(\pi)$.

The main problem with this data is that expected utility is an abstract concept that is not observable in reality. However, it is still possible to obtain a proxy for this variable based on the concept of utility itself used in modern economics. Before explaining how
this proxy was obtained, a brief revision of the concept of utility is presented as follows with the purpose of justifying the proxy adopted in this investigation.

Before the Second World War, cardinal utility was the dominant concept used in economics. Unfortunately, this concept considers real levels of individuals’ satisfaction which cannot be measured. As a consequence of this limitation, modern economics adopted the ordinal utility concept because it only requires knowing individuals’ preferences which can be identified, and not individuals’ levels of satisfaction (Deaton and Muellbauer, 1982; and van Praag, 1991). According to Dixon (1997), ordinal utility is a “number given to possible outcomes that can in some sense explain or predict choice” (p. 1812). That is, ordinal utility reflects an ordering of preferences over options (e.g. consumption sets). The relevance of this concept is that any scale can be assigned to utilities in order to represent preferences (Jehle and Reny, 2001). For example, suppose that an individual prefers A to B, and B to C. This can be represented by assigning a utility value equal to 10 to option A, 8 to option B and 2 to C. But this can also be represented by assigning an arbitrary number of 100 to option A, 0.2 to option B and 0.003 to option C. This is because in both cases A reports higher utility than B, and B higher utility than C which means that A is preferred to B, and B is preferred to C. In other words, any scale is meaningful to represent utilities. This is formally pointed out by Eaton et al. (1999): “These observations should make it clear that the economist’s theory of utility is a theory of ordinal utility, not cardinal utility. Utility numbers reveal only the relative ordering of consumption bundles (first, second, or third) and nothing about the distance between bundles in terms of desirability (twice as desirable or one-third as desirable)” (p. 62).
The main implication of this property of ordinal utility is that it can be rescaled without affecting its meaning in terms of individuals’ preferences. This is formally proved in Appendix P.

Using this notion of utility, farmers in the sample were asked to rank their preferences towards a set of ten crops (i.e. ten alternatives) chosen a priori (see Question 9 of the questionnaire in Appendix L) using an arbitrary but meaningful scale. That is, these farmers were asked to assign 10 to the most preferred crop and 1 to the least preferred. The resulting variable was defined as $U_{ik}$ and represented the preference ranking score assigned by farmer $i$ to crop $k$. For example, if a farmer assigned a value equal to 7 to carrots and 5 to potatoes, indicating that carrots were preferred by this individual when considering these two crops, then the value of the utility obtained by this farmer was 7 when selecting carrots and 5 when selecting potatoes.

On the other hand, it was found that statistics of gross margin of different crops from the public domain were not appropriate to represent the variable “expected gross margin” in the context of the experimental method. This is because using these statistics can bias the results. To see why, consider Table 2.3 in Chapter Two. According to this table, carrots have higher gross margin than parsnips. However, a farmer who does not produce these crops is probably less aware of the market conditions associated with these agricultural goods. As a consequence, it is possible that this farmer could erroneously indicate that parsnips have higher gross margin than carrots because he has this belief. Suppose now that this farmer indeed believed that the gross margin of parsnips is higher than that of carrots. Suppose in addition that this individual preferred parsnips to carrots. If this information on preferences was used with the statistics of gross margin available in the public domains, then the econometric model would
interpret that this farmer preferred the crop with the lower level of gross margin. However, this is not true because what really happened is that this farmer preferred the crop with higher gross margin because he believed that parsnips had higher level of gross margin than carrots.

In order to eliminate this source of bias, these ESBF in the sample were asked to assign 10 to the crop with larger gross margin and 1 to the crop with the smaller gross margin of the list of crops considered in the experimental method according to their previous market knowledge. The resulting variable was defined as \( x_{ik} \) and represented the gross margin ranking score assigned by farm \( i \) to crop \( k \).

Finally, in order to obtain an indicator of business risk, the ESBF in the sample were asked to assign a value of risk for each crop of the list according to the following scale: no risk (1); low risk (2); risky (3); very risky (4); and extremely risky (5). The resulting variable was defined as \( V_{ik} \) and represented the market risk ranking scored assigned by farm \( i \) to crop \( k \).

As explained above, in order to determine whether the ESBF of the sample had similar attitudes towards risk, a multiplicative dummy variable was assigned to each farmer participating in the experiment. The dummy was introduced as a multiplicative factor of variable \( V_{ik} \) to determine differences on attitudes toward risk which is reflected in the slope of this variable (see Figure 5.4). No differences in attitudes toward risk means, therefore, that the ESBF participating in the experiment had expected utility functions having similar slopes. In order to avoid the problem of perfect multicollinearity, one farmer was left without the dummy.
The regression models presented in Expressions 5.5 and 5.6 were introduced for illustrative purposes. However, a more complete and practical version of these regressions that includes the variables defined above is presented as follows:

\[ U_{ik} = \beta_0 + \beta_1 \tau_{ik} + \beta_2 V_{ik} + \sum_i \beta_i D_i V_{ik} \]  \hspace{1cm} (5.7)

Where \( \beta_0, \beta_1, \beta_2 \) and \( \beta_i \) are the regression coefficients, and \( D_i \) is the multiplicative dummy assigned to farmer \( i \). Since the EV analysis establishes that the utility increases when gross margin increases, it was expected to find that \( \beta_1 > 0 \). Risk averse behaviour, on the other hand, holds when \( \beta_2 < 0 \). If this is satisfied, then the HRA cannot be rejected. Finally, similar attitudes towards risk hold when none of the dummy variables are statistically significant. If this is verified, then the HSCRA cannot be rejected.

Formally, in order to determine whether the ESBF were risk averse, the null and alternative hypotheses of the HRA were reformulated as follows (see section 4.3.1):

\[ H_0: \beta_2 \geq 0 \]
\[ H_1: \beta_2 < 0 \]

If the null hypothesis is rejected, then the HRA holds. That is, if the null hypothesis is rejected, then it is concluded that the ESBF are risk averse.

The HSCRA, on the other hand, can be supported when none of the multiplicative dummy variables included in Expression 5.7 are statistically significant. In order to test
this hypothesis, the null and alternative hypotheses of the HSC were reformulated as follows:

\[ H_0: \beta_i = 0 \text{ for all } i \in \Omega, \text{ where } \Omega \text{ is the set of ESBF included in the sample.} \]

\[ H_1: \beta_i \neq 0 \text{ for at least one } i \in \Omega \]

**Step 2: Testing the HOP by estimating the EPL.** This step was designed to test the HOP (see section 4.3.1) by means of the estimation of the EPL. Because the latter is a function that links the expected gross margin of the portfolio of crops with its variance, that is \( E(\pi) = f(V(\pi)) \) (see Figure 4.10 and Appendix H), a linear regression model was employed to estimate this function. In order to capture non-linearity, the expected value and the variance of the gross margin of the portfolio of crops chosen by the ESBF were both expressed in terms of their natural logarithms. The regression model is presented as follows:

\[
\ln(E(\pi)) = \beta_0 + \beta_1 \ln(V(\pi)) \tag{5.8}
\]

where \( \ln(E(\pi)) \) and \( \ln(V(\pi)) \) are the natural logarithm of the expected gross margin and the variance of the gross margin of the portfolio, respectively, and \( \beta_0 \) and \( \beta_1 \) are the regression coefficients.

The HOP can be supported when the following condition is satisfied: \( \beta_1 < 0 \). This is because the EPL inferred from the multiple efficient frontiers theory has a negative slope as a result of the non-satiation assumption on preferences (see Figures 4.5 and 4.9). In order to determine whether the EPL existed, the null and the alternative hypotheses of the HOP were reformulated as follows:
\( H_0: \beta_i \geq 0 \)
\( H_1: \beta_i < 0 \)

If the null hypothesis is rejected, then the HOP holds.

**Step 3: Testing the HNE, HIC and the HSI using regression analysis on crop allocations.** According to the HNE, the HIC and the HSI, deviations around the *EPL* are explained by the incidence of non-economic drivers, self-motivation, and participation in collaborative alliances and social networks, respectively (see Sections 4.3.2 and 4.3.3 and Figure 4.13). The assumption made with respect to these deviations is that they represent differences in farmers’ goals; attitudes toward farming; perceived behavioural control; subjective norms; attitudes toward business strategies; market and material resources barriers; self-motivation; and attitudes towards different business strategies such as participation in collaborative alliances and social networks among the farmers in the sample. This assumption has been used as the basis to test the HNE, the HIC and the HSI in the present study.

In order to test these hypotheses, a stepwise linear regression model was employed which extended the model presented in expression 5.8. To understand why this regression can be used to test these hypotheses, let us consider the following example. Suppose that only farmer \( i \) deviates from the *EPL*. This case is shown in Figure 5.5:
Figure 5.5 Single Deviation from the EPL by Farmer $i$

In this figure all farmers $j \neq i$ are located along the EPL. This implies that their crop allocations are described by Equation 5.8. Suppose now that the deviation from this line by farmer $i$ is due to the incidence of a goal that only this farmer considers when making cropping decisions. Let $G_i$ be this goal. A way to represent this deviation is to add this variable in equation 5.8 as follows:

$$\ln(\mathbb{E}(\pi)) = \beta_0 + \beta_1 \ln(V(\pi)) + \beta_i G_i$$

(5.9)

where the coefficient $\beta_i$ represents how important the effect of this goal is. The inclusion of the term $\beta_i G_i$ implies that the intercept of the original equation has changed from $\beta_0$ to $\beta_0 + \beta_i G_i$. As a result, expression 5.9 is a parallel line to the original EPL presented in Equation 5.8. This is shown in Figure 5.6:
Logarithm of the Variance of Gross Margin: $Ln(V(\pi))$

$\beta_0 + \beta_i G_i$

$\beta_0$

Parallel line to the $EPL$

Figure 5.6 Deviation around the $EPL$ explained by a Goal $G_i$

It is possible to infer from this example that if the coefficient $\beta_i$ is statistically significant (i.e. different from zero), the deviation from the original $ELP$ curve is explained by the goal $G_i$. In contrast, if this coefficient is not statistically significant, then the deviation is not explained by the occurrence of this goal.

Generalising the argument presented in this example, a way to test the HNE, the HIC and the HSI is to add the variables that generate deviations around the $EPL$ (i.e. around the equation presented in Expression 5.8). This is the approach that was adopted in the present research. According to the HNE, these variables correspond to farmers’ goals; farmers’ attitudes toward farming; perceived control; subjective norms; and market and material resources barriers. According to the HIC, differences in self-motivation among farmers also generate deviations around the $EPL$. Finally, according to the HIS,
differences in farmers’ attitudes towards forming collaborative alliances and social networks can also generate deviations towards the *EPL*. Let $G_i$, $A_j$, $P_k$, $N_l$, $MB_m$, $MRB_n$, $SM_o$, $CA_p$, and $SN_q$ denote farmers’ goals, farmers’ attitudes toward farming, perceived behavioural control, subjective norms, market barriers, material resources barriers, self-motivation, collaborative alliances, and social networks, respectively. Considering all these sources of deviations, the regression model used to test the HNE was defined as follows:

$$
\ln(E(\pi)) = \beta_0 + \beta_1 \ln(V(\pi)) + \sum_i \beta_i G_i + \sum_j \beta_j A_j + \sum_k \beta_k P_k + \sum_l \beta_l N_l + \sum_m \beta_m MB_m + \sum_n \beta_n MRB_n + \beta_o SM_o + \beta_p CA_p + \beta_q SN_q
$$

(5.10)

The data used in this regression for the variables that represent deviations around the *EPL* is explained as follows.

(i) **Farmers’ goals** ($G_i$): Farmers’ goals were obtained from the questionnaire using a five points Likert scale for statements on farmers’ goals that were adapted from Bergevoet et al. (2004) and Willock et al. (1999) (see Question 6 of the questionnaire in Appendix L).

(ii) **Farmers’ attitudes toward farming** ($A_j$): Farmers’ attitudes toward farming were obtained from the questionnaire using a five points Likert scale for statements on farmers’ attitudes toward farming that were adapted from Bergevoet et al. (2004) and Willock et al. (1999) (see Question 7 of the questionnaire in Appendix L).
(iii) Perceived behavioural control ($P_b$): Variables representing perceived behavioural control were obtained from the questionnaire using a five points Likert scale for statements that were adapted from Bergevoet et al. (2004) and Willock et al. (1999) (see Question 7 of the questionnaire in Appendix L).

(iv) Subjective norms ($N_s$): Variables representing subjective norms were obtained from the questionnaire using a five points Likert scale for statements that were adapted from Bergevoet et al. (2004) and Willock et al. (1999) (see Question 7 of the questionnaire in Appendix L).

(v) Market barriers ($MB_n$): Different statements based on the literature review on market barriers (see Section 3.6) were introduced in the questionnaire with the objective of identifying market barriers that prevented farmers from selecting crops with higher levels of gross margin. A five points Likert scale was used to measure these statements (see Question 5 of the questionnaire in Appendix L).

(vi) Material resources barriers ($MRB_o$): It was not possible to obtain data related to material resources barriers because farmers were unwilling to report this information. In order to obtain a proxy for material resources barriers, farmers were asked to report the importance that they attributed to the business strategies of diversification and specialisation using a five points Likert scale (see Question 8 of the questionnaire in Appendix L). The rationale for using these proxies is explained as follows.

Suppose that a farmer specialised in the production of cereals and for this purpose he/she had machinery that was specialised for the production of these crops. If this individual faced material resources barriers prevented him/her from investing in more
expensive machinery needed to produce crops with high levels of gross margin, then this farmer would not be able to diversify into these crops. As a consequence, if this farmer was asked whether specialisation was a useful strategy for his/her farm, then this individual would probably agree to this statement. In contrast, if this farmer did not face these barriers, then he/she would probably indicate that diversification was a useful strategy for his farm. Unfortunately this proxy is not accurate. Nonetheless, it was the only available variable related to material resources barriers that was possible to obtain from the sample.

(vii) **Self-motivation (SM)**: In order to determine farmers’ self-motivation, these individuals were asked to use a five points Likert scale for the statements “I am not interested in producing other crops with higher gross margin” and “I am not familiar with the productive process of crops with higher gross margin”. These statements were located in the section of market barriers because they were considered as psychological market barriers that prevented farmers from adopting crops with higher levels of gross margin (see Question 5 of the questionnaire in Appendix L).

(viii) **Collaborative alliances (CA)**: Farmers’ attitudes toward collaborative alliances were obtained from the questionnaire using a five points Likert scale (see Question 8 of the questionnaire in Appendix L).

(ix) **Social networks (SN)**: Farmers’ attitudes toward social networks in both the free and contract markets were obtained from the questionnaire using a five points Likert scale (see Question 8 of the questionnaire in Appendix L).
Using Equation 5.10, the null and the alternative hypotheses of HNE were reformulated as follows:

\[ H_0: \beta_i = \beta_j = \beta_k = \beta_m = \beta_n = 0 \]
\[ H_1: \beta_i \neq 0, \text{ or } \beta_j \neq 0, \text{ or } \beta_k \neq 0, \text{ or } \beta_m \neq 0, \text{ or } \beta_n \neq 0 \]

That is to say, the null hypothesis establishes that none of the non-economic drivers, market barriers and material resources barriers (i.e. \( G_i, A_j, P_k, N_l, MB_m, MRB_n \)) is statistically significant. If this hypothesis is rejected, then the HNE holds.

On the other hand, the null and the alternative hypotheses of HIC in terms of Equation 5.10 were reformulated as follows:

\[ H_0: \beta_0 = 0 \]
\[ H_1: \beta_0 \neq 0 \]

That is to say, the null hypothesis establishes that self-motivation is not statistically significant. If this hypothesis is rejected, then the HIC holds.

Finally, the null and the alternative hypotheses of HSI in terms of Equation 5.10 were reformulated as follows:

\[ H_0: \beta_p = \beta_q = 0 \]
\[ H_1: \beta_p \neq 0, \text{ or } \beta_q \neq 0 \]
That is to say, the null hypothesis establishes that collaborative alliances and social networks are not statistically significant. If this hypothesis is rejected, then the HSI holds.

5.3.5 Methods adopted in the Dynamic Stage of the Research and Farmers’ Classification

5.3.5.1 Methods adopted in the Dynamic Stage of the Research

The aim of the static stage of the research presented in the last section was to determine economic and non-economic drivers that explained the cropping choices made by the ESBF after the closure of the ESBF. An interesting question that arose from this static stage was how these farmers would behave if material resource barriers were removed from this analysis. The objective of the present section is to answer this question by means of an experimental method. In this method farmers were asked to report the crop allocations that they would choose if they were given all the material resources needed to develop dynamic capabilities (see Question 10 of the questionnaire in Appendix L). The information provided by the respondents was used to determine the portfolios of crops that they would choose in response to this shock. Following the same methodology used in Phase III of the static stage of the research, the expected value and the variance of the gross margin of these portfolios were both calculated for each farmer. The research strategy adopted to determine the impact of the removal of material resource barriers was to compare the real portfolios of crops chosen by the ESBF in 2008 (i.e. the portfolio of crops considered in Phase III of the static stage of the research) with the hypothetical portfolios reported by them in the experiment. The HAE and the HAD were tested using this comparison.
In order to test the HAD, this comparison was made using a single regression model. To understand how this model works, let us consider an example. Suppose, for simplicity, that the sample was composed of three farmers: farmers $i$, $j$ and $k$. The expected gross margin of the portfolios of crops chosen by these individuals before the shock are $E(\pi)_{ib}$, $E(\pi)_{jb}$ and $E(\pi)_{kb}$, respectively. Likewise, the expected gross margin of the portfolios of crops chosen by these individuals after the shock are $E(\pi)_{ia}$, $E(\pi)_{ja}$ and $E(\pi)_{ka}$, respectively. On the other hand, the variance of the gross margin of the portfolios of crops chosen by these farmers before the shock are $V(\pi)_{ib}$, $V(\pi)_{jb}$ and $V(\pi)_{kb}$, respectively. Likewise, the variance of the gross margin of the portfolios of crops chosen by these individuals after the shock are $V(\pi)_{ia}$, $V(\pi)_{ja}$ and $V(\pi)_{ka}$, respectively.

Table 5.3 shows this data organised as a data pool:

<table>
<thead>
<tr>
<th>Observation (farmer)</th>
<th>Expected gross margin</th>
<th>Variance gross margin</th>
<th>Dummy variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$E(\pi)_{ib}$</td>
<td>$V(\pi)_{ib}$</td>
<td>$B_i$ $B_j$ $B_k$ $A_i$ $A_j$ $A_k$</td>
</tr>
<tr>
<td>$i$</td>
<td></td>
<td></td>
<td>1 0 0 0 0 0</td>
</tr>
<tr>
<td>$j$</td>
<td></td>
<td></td>
<td>0 1 0 0 0 0</td>
</tr>
<tr>
<td>$k$</td>
<td></td>
<td></td>
<td>0 0 1 0 0 0</td>
</tr>
<tr>
<td>$i$</td>
<td>$E(\pi)_{ia}$</td>
<td>$V(\pi)_{ia}$</td>
<td>0 0 0 1 0 0</td>
</tr>
<tr>
<td>$j$</td>
<td>$E(\pi)_{ja}$</td>
<td>$V(\pi)_{ja}$</td>
<td>0 0 0 0 1 0</td>
</tr>
<tr>
<td>$k$</td>
<td>$E(\pi)_{ka}$</td>
<td>$V(\pi)_{ka}$</td>
<td>0 0 0 0 0 1</td>
</tr>
</tbody>
</table>

The information presented in this table can be considered as a single piece of data (i.e. data pool) composed of six observations, where each farmer is considered twice: before and after the technological improvement. The table also includes dummy variables for each farmer. The dummies $B_i$, $B_j$ and $B_k$ have been introduced with the objective of
identifying outliers before the incidence of the shock. In contrast, the dummies $A_i$, $A_j$ and $A_k$ have been introduced to identify outliers after the occurrence of the technological improvement. In other words, following the reasoning given in Step 3 of Phase III, the dummies $A_i$, $A_j$ and $A_k$ capture deviations from the EPL. The only difference is that in this case the EPL is estimated using the data pool rather than the data obtained from single observations. The regression for the example given in Table 5.3 is given by:

\[
\begin{align*}
\ln(E(\pi)) &= \beta_0 + \beta_1 \ln(V(\pi)) + \beta_{ib} B_i + \beta_{jb} B_j + \beta_{kb} B_k + \beta_{ia} A_i + \beta_{ja} A_j + \beta_{ka} A_k \\
\end{align*}
\]  
(5.11)

Where $\beta_{ib}$, $\beta_{jb}$, $\beta_{kb}$, $\beta_{ia}$, $\beta_{ja}$, and $\beta_{ka}$ are the regression coefficients of the dummy variables. Suppose now that all the farmers were located on the EPL before the incidence of the exogenous shock and that only farmer $k$ departed from the EPL in response to this shock (i.e. this farmer becomes an outlier after the shock). This implies that the only statistically significant dummy variable is $A_k$. As a consequence, the model presented in Expression 5.11 converges to:

\[
\begin{align*}
\ln(E(\pi)) &= \beta_0 + \beta_1 \ln(V(\pi)) + \beta_{ka} A_k \\
\end{align*}
\]  
(5.12)

As can be seen in this equation, the dummy that was found to be statistically significant can be used to identify the farmers who departed from the EPL. The rest have moved along this line, or have remained in the same relative position as before. This is the concept used to identify how farmers responded to the technological improvement in the current research. This model has been generalised to include all the farmers in the sample as follows:
As explained in the example, if farmer $i$ was on the $EPL$ before the exogenous shock and if the dummy variable $A_i$ was found to be significant, then this implied that this farmer had departed from the $EFL$ after the technological change. In contrast, if the dummy variable $A_i$ was not significant, then farmer $i$ had moved along the $EFL$ or remained in the same position in response of the technological improvement.

Using Equation 5.13, the null and the alternative hypotheses of HAD were reformulated as follows:

$$\text{H}_0: \beta_i = 0$$

$$\text{H}_1: \beta_i \neq 0$$

This condition says that if the null hypothesis is rejected, then the HAD holds for farmer $i$. That is, in this case it is concluded that this farmer departed from the $EPL$ after the technological change.

On the other hand, the following strategy was adopted to test the HAE. The farmers who did not depart from the $EPL$ (i.e. the null hypothesis of HAD was not rejected for these farmers) were identified and grouped in a subset of farmers called the non-outliers. The following variables were used to characterise this subset:
(i) $GM_B$: Sample mean of the gross margin of the portfolios of crops chosen by the non-outliers before the incidence of the exogenous shock;

(ii) $GM_A$: Sample mean of the gross margin of the portfolios of crops chosen by the non-outliers after the incidence of the exogenous shock;

(iii) $VGM_B$: Sample variance of the gross margin of the portfolios of crops chosen by the non-outliers before the incidence of the exogenous shock;

(iv) $VGM_A$: Sample variance of the gross margin of the portfolios of crops chosen by the non-outliers after the incidence of the exogenous shock.

(v) $BR_B$: Sample mean of the business risk of the portfolios of crops chosen by the non-outliers before the incidence of the exogenous shock;

(vi) $BR_A$: Sample mean of the business risk of the portfolios of crops chosen by the non-outliers after the incidence of the exogenous shock;

(vii) $VBR_B$: Sample variance of the business risk of the portfolios of crops chosen by the non-outliers before the incidence of the exogenous shock;

(viii) $VBR_A$: Sample variance of the business risk of the portfolios of crops chosen by the non-outliers after the incidence of the exogenous shock;

According to the theory developed in the current research, the HAE can only hold when two conditions are verified simultaneously: (i) the average of the gross margin of the
portfolio of crops chosen by the non-outliers increases after the shock; and (ii) the average of business risk of the portfolio of crops chosen by these farmers decreases after the shock. This is because moving upwards along the EPL requires these conditions to be verified. This provides the opportunity to test the HAE using the following null and alternative hypotheses:

\[ H_0: \text{GM}_B = \text{GM}_A; \text{ or BR}_B = \text{BR}_A \]

\[ H_1: \text{GM}_B < \text{GM}_A; \text{ and BR}_B > \text{BR}_A \]

If the null hypothesis is not rejected, then the HAE cannot be supported because \( H_1 \) is a necessary condition for this hypothesis to hold. In order to test these hypotheses, two Student \( t \)-tests were conducted: one to determine whether the \( \text{GM}_B = \text{GM}_A \); and the other to determine whether \( \text{BR}_B = \text{BR}_A \).

### 5.3.5.2 Farmers’ Classification

In order to classify and cluster farmers in terms of their strategic responses to technological change, the Income-Risk Matrix criterion was adopted (see Section 4.4.2). Each class of farmers included individuals who chose a similar strategy in response to exogenous shock according to this criterion. In order to determine whether different strategic responses across classes were explained by differences in economic and non-economic drivers (i.e. farmers’ goals; attitudes towards farming; perceived behavioural control; subjective norms; attitudes towards different business strategies; and market barriers), Student \( t \)-tests were conducted. For example, suppose that two classes were identified: class A and class B. Let \( \overline{G}_{iA} \) and \( \overline{G}_{iB} \) be the five point Likert scale sample means of the goal \( i \) for classes A and B, respectively. In order to determine whether the
difference between the strategies adopted by these classes is explained by this goal, the following test was conducted:

\[ t = \frac{G_{iA} - G_{iB}}{SD_{AB}} \]  

(5.14)

Where \( SD_{AB} \) is defined as:

\[
SD_{AB} = \left\{ \frac{1}{n_A/n_B} \left[ \frac{\sum G_{iA} - \left( \sum G_{iA} \right)^2}{n_A} + \frac{\sum G_{iB} - \left( \sum G_{iB} \right)^2}{n_B} \right] \right\}^{1/2} \left[ \frac{n_A + n_B - 2}{n_A + n_B} \right]
\]

(5.15)

where \( n_A \) and \( n_B \) are the numbers of farmers in classes A and B, respectively. This definition for the Student \( t \)-test, with \( n_A + n_B - 2 \) degrees of freedom, is suitable for small sample sizes (Upton and Cook, 1996).

Using this technique for all the statements included in the questionnaire, it was possible to identify the economic and non-economic drivers that characterised each class of farmers. These drivers were considered the factors that explained why these classes of farmers had adopted different strategies in response to technological shock.

5.3.6 Additional Econometric Tests
In order to determine whether the coefficients estimated by the econometric models adopted in the static and dynamic stages of the research were reliable and unbiased, two econometric tests were conducted in these regressions (Green, 2007): (1) the Jarque-Bera test of normality; and (2) the White Heteroskedasticity test. The first test permits determining whether the residual term of a regression model comes from a normal distribution which is a requirement to determining whether the coefficients estimated by this model are statistically significant. The White Heteroskedasticity test, on the other hand, permits determining whether the variance of the residual term of a regression is the same for all observations (i.e. whether the residuals are homoskedastic). Heteroskedasticity normally appears when using cross section data (Green, 2007). This is why conducting this test in the regressions adopted in this thesis was fundamental to validate the results as the data used in the investigation was cross sectional.

5.4 Chapter Summary

The objective of this chapter is to describe the methodology adopted to test the hypotheses established in the last chapter (i.e. the HRA, HSCRA, HOP, HNE, HIC, HIS, HAD, and HAE). It starts by explaining that the validation of these hypotheses requires testing causal relationships inferred from the proposed multivariate model. As a consequence, the positivistic approach was adopted to conduct the empirical part of the investigation. A questionnaire using closed questions was developed with the purpose of collecting the information that was needed to test the hypotheses.

The research consisted of a pilot investigation, a static stage of the research and a dynamic stage of the research. The aim of the static stage of the research was to
investigate the factors that explain the cropping choice made by the ESBF in response to the closure of the ASBF. On the other hand, the objective of the dynamic stage of the research was to investigate how the ESBF would strategically behave if they were given all the material resources needed to develop dynamic capabilities.

The objective of the next chapter is to use some of the methods and research strategies described in the present chapter to test six of the hypotheses established in this thesis: the HRA, HSCRA, HOP, HNE, HIC and the HIS. In other words, the focus of the next chapter is to present the results of the static stage of the research.

**Chapter Six: FINDINGS AND RESULTS IN THE STATIC STAGE OF THE RESEARCH**

As previously outlined in the literature review, Clothier (2010) and Department for Environment Food and Rural Affairs (2010a) suggest that the ex-sugar beet farmers of the West Midlands region (ESBF) adjusted to the closure of the sugar factory located at Allscott (ASBF) by replacing sugar beet with crops with low gross margin (mainly oilseed rape, wheat and barley). The review also suggested a number of alternative approaches that might be used to explain why farmers had apparently opted for this crop choice. These approaches were used to develop a holistic multivariate model with the objective of explaining farmers’ decision regarding crop allocations (see Figure 4.2). The approaches considered by this model are presented in the following figure:
As shown in Chapter Four, the model based on the approaches presented in this figure provided behavioural predictions that were formalised as eight testable hypotheses. The aim of the present chapter is to test six of these hypotheses (the first six hypotheses listed in the introduction of Chapter Five) with the purpose of explaining why the ex-sugar beet farmers (ESBF) chose crops with low gross margin in response to the closure of the Allscott sugar factory (ASBF).

The chapter is organised as follows. Section 6.1 presents the results of the pilot investigation. Section 6.2 gives the results of Phase I of the static stage of research. Section 6.3 presents the results obtained in Phase II. Section 6.4 gives the results obtained in Phase III of the static analysis. Finally, Section 6.5 concludes the chapter.

6.1 Findings from the Pilot Investigation
The pilot investigation was developed with the objective of facilitating the development of indicators that would form the questionnaire to be used in the present research. As outlined in Chapter Five, the method for the pilot analysis was based on two stages. The first consisted of interviewing relevant agents using semi-structured questions with the objective of gaining an initial understanding of the way in which the ESBF adjusted to the closure of the ASBF. The information collected in this stage and the antecedents obtained from the literature were both used to design a draft of the questionnaire used in the research. In the second stage of the pilot investigation the draft was pre-tested with ten ESBF. The development and results of these stages are presented as follows.

6.1.1 First Stage of the Pilot Investigation

Some important facts were identified in the first stage of the pilot investigation that supported the idea that non-economic drivers were involved in farmers’ cropping decisions as predicted by the multivariate model proposed in this thesis. First, one of the interviewees stated that he preferred to produce non-time consuming crops in order to enjoy his lifestyle. This farmer argued that because he was relatively old, he was not willing to spend the rest of his life working in stressful and time demanding conditions, but would rather enjoy working at his own pace. This case suggests that some farmers could be willing to give up some levels of income in order to have more free time to develop non-productive activities. This, in turn, means that some farmers were not necessarily gross margin maximisers.

A second factor emerging from the interviews was that, some of the interviewees claimed that market barriers prevented them from choosing crops with higher levels of
gross margin. The most important barrier was power imbalance in the interface retailers and producers. They explained that retailers have the option to buy crops from a significant number of farmers. In contrast, the farmers have few options when it comes to selling their produce. As a consequence, farmers are obligated to accept low prices for their crops. They also reported that retailers demand quality that is difficult to achieve given their land quality constraints and also the effects of bad weather on their production. In addition, retailers sometimes demand volumes that cannot be produced given their limited productive capacity, and this capacity cannot be expanded as a consequence of capital constraints and lack of collaboration among farmers. These individuals argued that all these market barriers negatively affect farmers’ capacity to adopt crops with higher levels of gross margin.

A third element emerging from the interviews was that some farmers felt that the formation of collaborative alliances was the most important business strategy in order to overcome these market barriers and to reduce production costs. However, they argued that farmers are prevented from forming these alliances because they are limited by two main constraints: distrust and administration costs. According to the farmers, distrust arises as a consequence of the existence of potential bad partners (i.e. adverse selection). The latter are individuals who share the benefits of collaboration, but are unwilling to share the work tasks in a fair way.

The information collected from the interviewees was complemented with a literature review on related academic work studying farmers’ strategic behaviour. The sources were used to develop a questionnaire with 59 statements associated with the theoretical domains of the approaches listed in Figure 6.1. Most of these statements were extracted and adapted from Bergevoet et al. (2004) and Willock et al. (1999).
6.1.2 Second Stage of the Pilot Investigation

In the second stage of the pilot investigation a set of ten farmers was asked to answer a draft of the questionnaire to test its face validity. This term corresponds to a rating of the suitability of a test for its intended use (Nevo, 1985). Following the research strategy adopted by Broder et al. (2007), face validity was conducted in the present investigation to assess the clarity of the wording of the statements included in the questionnaire; and to generate new statement from the respondents.

The questionnaire appeared to be appropriate in general terms and the farmers in the pilot sample understood the wording of the statements without problem. However, these individuals provided important advice and feedback that assisted in the improvement of the questionnaire. In particular, one farmer said that the list of business strategies considered in the questionnaire should also include collaborative alliances to reduce costs. This individual explained that the formation of collaborative alliances is not a common practice. Nonetheless, he was the exception because he formed a successful alliance with a partner.

The pilot investigation also revealed important results that were consistent with the predictions obtained from the proposed multivariate model. First, it was possible to identify non-economic drivers that were considered relevant for the farmers included in the pilot sample. This is formally shown in Table 6.1 which presents the average, maximum value, minimum value and standard deviation of the five points Likert scores (Strongly disagree = 1; Disagree = 2; Indifferent = 3; Agree = 4; and Strongly agree =
5) assigned by the farmers in the pilot investigation to indicate the relevance that they put to the goals listed in Question 6 in the questionnaire (see Appendix L).

Table 6.1 Farmers’ goals

<table>
<thead>
<tr>
<th>Statement on Goals</th>
<th>Mean</th>
<th>Max</th>
<th>Min</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Achieve an income as high as possible</td>
<td>4.3</td>
<td>5.0</td>
<td>2.0</td>
<td>0.8</td>
</tr>
<tr>
<td>b) Enjoy my work</td>
<td>4.5</td>
<td>5.0</td>
<td>4.0</td>
<td>0.5</td>
</tr>
<tr>
<td>c) Provide for next generations</td>
<td>3.6</td>
<td>4.0</td>
<td>3.0</td>
<td>0.8</td>
</tr>
<tr>
<td>d) Have sufficient time for leisure</td>
<td>3.8</td>
<td>5.0</td>
<td>2.0</td>
<td>0.9</td>
</tr>
<tr>
<td>e) Maintain nature and environmental value</td>
<td>3.8</td>
<td>5.0</td>
<td>2.0</td>
<td>0.8</td>
</tr>
<tr>
<td>f) Produce a good and safe product</td>
<td>4.5</td>
<td>5.0</td>
<td>4.0</td>
<td>0.6</td>
</tr>
<tr>
<td>g) Gaining recognition and prestige as a farmer</td>
<td>3.3</td>
<td>5.0</td>
<td>2.0</td>
<td>0.9</td>
</tr>
<tr>
<td>h) Belonging to the farming community</td>
<td>3.8</td>
<td>5.0</td>
<td>3.0</td>
<td>0.7</td>
</tr>
<tr>
<td>i) Maintaining the family tradition</td>
<td>3.0</td>
<td>4.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>j) Working with other members of the family</td>
<td>3.5</td>
<td>4.0</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>k) Feeling pride of ownership</td>
<td>4.1</td>
<td>5.0</td>
<td>3.0</td>
<td>0.7</td>
</tr>
<tr>
<td>l) Enjoyment of work tasks</td>
<td>4.0</td>
<td>5.0</td>
<td>3.0</td>
<td>0.5</td>
</tr>
<tr>
<td>m) Preference for a healthy, outdoor, farming life</td>
<td>4.5</td>
<td>5.0</td>
<td>3.0</td>
<td>0.6</td>
</tr>
<tr>
<td>n) I enjoy having a purpose and value hard work</td>
<td>4.2</td>
<td>5.0</td>
<td>3.0</td>
<td>0.6</td>
</tr>
<tr>
<td>o) Have independence and freedom from supervision</td>
<td>4.2</td>
<td>5.0</td>
<td>3.0</td>
<td>0.8</td>
</tr>
<tr>
<td>p) Have the control in a variety of situations</td>
<td>4.2</td>
<td>5.0</td>
<td>3.0</td>
<td>0.8</td>
</tr>
</tbody>
</table>

This table shows that farmers assigned on average different scores to the statements representing farmers’ goals. The highest value (i.e. 4.5) was assigned to the goals “enjoying my work”, “produce a good and safe product”, and “preference for a healthy,
outdoor, farming life”. This finding reveals that the farmers in the pilot analysis put high importance (i.e. they strongly agreed as inferred from the average score of 4.5) to non-economic goals that involve quality of life and enjoyment. This suggests, therefore, that non-economic goals could eventually affect farmers’ strategic behaviour. For example, a farmer who strongly values the goal “preference for a healthy, outdoor, farming life” could be prevented from taking the opportunity to work off farm in an office even if this choice provides him/her higher levels of income.

The goal that follows in terms of the score assigned by the farmers (i.e. 4.3) is “achieve an income as high as possible”. This means that, calculated as an average score, the farmers in the pilot investigation agreed to this statement implying that achieving the highest possible income (i.e. maximising income) was an objective for these farmers. It is interesting to notice, however, that even when this goal was important for the farmers in the pilot investigation, other non-economic goals were even more important for these individuals as discussed above. This, therefore, provides additional support to the idea that non-economic drivers could influence farmers’ strategic behaviour which is the hypothesis explored in this thesis.

Other important goals in terms of the score assigned by the farmers are “I enjoy having a purpose and value hard work”, “Have independence and freedom from supervision”, and “Have the control in a variety of situations”. The farmers in the pilot investigation assigned on average a score equal to 4.2 meaning that they agreed to these statements. This finding reveals, in particular, that the capacity to make decisions without supervision and to have control over different situations was relevant for these farmers. This, again, suggests that non-economic goals could play an important role in farmers’ decision making. For example, cropping choices made by a farmer who has not freedom
from supervision could strongly be limited if this individual has a supervisor who is unwilling to innovate.

The farmers in the pilot investigation also indicated on average that the goals “Feeling pride of ownership”, “Belonging to the farming community”, “Enjoyment of work tasks”, “Have sufficient time for leisure”, and “Maintain nature and environmental value”, are important for them (although less important than the goals described above). The first two goals, in particular, suggest that social aspects of the farm (e.g. farming community and the need for social recognition associated with the goal feeling pride of ownership) could also affect farmers’ strategic behaviour. Consequently, non-economic drivers affecting farmers’ behaviour could not only involve psychological variables, but also social considerations such as being in contact with the farm community. The other goals, in contrast, seem to be more related to personal interests. Even though, they correspond to non-economic goals that could also affect farmers’ strategic cropping decisions. For example, a farmer who cares about maintaining nature and environmental values will probably adopt less intensive productive activities. Likewise, a farmer who values time for leisure will probably adopt less time demanding productive activities. But these choices are a reflexion of the influence of these goals on farmers’ cropping decisions.

Surprisingly, the goals “Provide for next generations” and “Working with other members of the family” were less relevant for the farmers in the pilot investigation than the other goals described above. This suggests that family considerations could cause little influence on cropping decisions made by these individuals.
Finally, the farmers in the pilot investigation responded on average that they were indifferent with respect to the goals “Maintaining the family tradition” and “Gaining recognition and prestige as a farmer”. Regarding the first goal, this finding suggests that family considerations could cause little influence on cropping decisions made by the farmers in the pilot investigation. The second goal, on the other hand, needs to be interpreted with caution. As discussed above, these farmers apparently cared about gaining recognition in terms of feeling pride of ownership. However, they did not care about gaining recognition and prestige as a farmer. This suggests therefore that it was ownership and not being a farmer what was valued by these individuals as a way of gaining social recognition.

In summary, the results presented in Table 6.1 suggest that not only economic goals were involved in farmers’ cropping decisions, but also goals that have social and psychological dimensions as hypothesised in this thesis.

On the other hand, the second main result that was found in the pilot investigation is that it was possible to detect a negative relationship between the expected gross margin and business risk of the portfolio of crops reported by these farmers. This relationship is consistent with the theoretical efficient portfolio line (\(EFL\)) deduced from the multiple efficient frontiers theory (MEFT) proposed in Chapter Four (see Figure 4.10) and is shown in Figure 6.2:
Figure 6.2 Relationship between Expected value and variance of the gross margin of the portfolio of crops chosen by the farmers in the pilot investigation.

In order to gain a better understanding of the implications of this figure, let us consider some concepts revised in previous chapters. Remember that it is explained in Section 3.3.2.2 that farmers normally establish a number of crops at present with the objective of obtaining a future gross margin after harvesting the production. This temporal delay between sowing and harvesting has important implications in terms of farmers’ strategic cropping decisions because they have to make expectations about the future gross margin that they will obtain after harvesting. A common strategy used to introduce expectations in this context is to assume that farmers have adaptive expectations (Dougherty, 2007). That is, it is assumed that farmers consider the weighted average of historical levels of gross margin obtained in the past as an estimator of future gross margin (concrete examples of how the expected gross margin defined in this way is calculated are presented in Appendices E, I, J and K).
As discussed in Section 3.3.2.2, this estimator of future gross margin (i.e. expected gross margin) is not perfect because the level of gross margin is not constant and, consequently, it is difficult to predict with certainty future levels of gross margin using historical data. The reason is because the level of gross margin is affected by a number of factors that cannot be predicted. This implies that the incidence of these factors in the past are incorporated in the historical data meaning that this data has noise. As explained in Footnote 1 in Chapter One, this uncertainty in gross margin is referred to as business risk (the indicator used as a measure of business risk is described in Footnote 2 in Chapter Two and in Section 5.3.4.3).

According to the MEFT proposed in Section 4.3.1, farmers who face this uncertainty have an incentive to maximise expected gross margin and to minimise the associated business risk simultaneously by choosing a convenient mix of crops in the portfolio. However, because they face different market and resource constraints (e.g. lack of irrigation, different land quality, etc), they cannot obtain the same optimal levels of expected gross margin and business risk even when adopting the same crops. According to this theory, farmers facing less market and resources barriers tend to choose crops with higher levels of expected gross margin and lower levels of business risk which is actually what it is shown in Figure 6.2.

This figure shows the levels of expected of gross margin and business risk of the portfolio of crops formed by nine farmers who participated in the pilot investigation. These variables were calculated using the information provided by these individuals in Question 4 of the first draft of the questionnaire used in the pilot investigation (see Question 4 of the questionnaire presented in Appendix L) and the statistics presented in
the Agricultural Budgeting & Costing Book (see Agro Business Consultants in the references). A trend line was added in this figure to show that these combinations of expected gross margin and business risk chosen by each farmer (the points in grey) follow the trend line which is consistent with the predictions of the MEFT. Two see that, two arbitrary farmers were identified in this figure for illustrative purpose: farmer \textit{a}; and farmer \textit{b}. Farmer \textit{a} corresponds to Observation 1 of the pilot investigation and is an individual who chose a portfolio composed of wheat, barley, oilseed rape, oats and potatoes. Farmer \textit{b}, on the other hand, corresponds to Observation 7 of the pilot investigation and is an individual who chose a portfolio of crops formed of wheat, barley, oilseed rape and potatoes. These two portfolios are very similar in terms of composition. However, the proportion of crops in the mix is different, as shown in the following table:

Table 6.2 Proportion of crops adopted by Farmers \textit{a} and \textit{b} in their portfolio of crops.

<table>
<thead>
<tr>
<th>Crops adopted in the portfolio</th>
<th>Proportion (%) of crops chosen by Farmer \textit{a}</th>
<th>Proportion (%) of crops chosen by Farmer \textit{b}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>32</td>
<td>36</td>
</tr>
<tr>
<td>Barley</td>
<td>35</td>
<td>21</td>
</tr>
<tr>
<td>Oilseed rape</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Oats</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Potatoes</td>
<td>7</td>
<td>25</td>
</tr>
</tbody>
</table>

According to this table, both farmers covered their land with a high proportion of wheat and a relatively similar proportion of oilseed rape. However, the main difference is that
farmer b adopted a higher proportion of potatoes. In contrast, farmer a adopted a smaller proportion of this crops but a higher proportion of barley and also introduced oats. It is therefore not surprising that farmer b reached a better position along the trend line in Figure 6.2 (i.e. higher level of expected gross margin per unit of business risk) than farmer a because potatoes has a higher level of gross margin than traditional crops (see Table 3.2). This suggests that farmer a would have been able to improve his/her position in Figure 6.2 by increasing the proportion of potatoes in the portfolio of crops as farmer b did. The main question is why farmer a did not select a higher proportion of potatoes. According to the MEFT proposed in this thesis, this is because farmer b faced less market or resources barriers than farmer a. As a consequence, farmer b was able to choose a portfolio of crops that permitted him/her to reach a better potion along the trend line presented in Figure 6.2. In order to determine whether this prediction was verified in this example, the scores reported by these farmers in Question 5 of the draft of the questionnaire were compared (see Question 5 in Appendix L). In this question, the farmers in the pilot investigation were asked to use a five points Likert scale (Strongly disagree = 1; Disagree = 2; Indifferent = 3; Agree = 4; and Strongly agree = 5) to report the importance that they attributed to some specific market barriers. The following table shows the barriers that were found to be most relevant in explaining the different cropping choices made by these individuals:

Table 6.3 Different barriers faced by farmers a and b.

<table>
<thead>
<tr>
<th>Market Barriers</th>
<th>Likert score assigned by Farmer a</th>
<th>Likert score assigned by Farmer b</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) My land is not appropriate to produce these crops with high levels of gross margin.</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>(b) I don’t have the necessary capital and machinery to produce</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>
these crops.
(c) Retailers demand a volume that I cannot produce.
(d) I am not able to innovate to the extent required to enter the market of crops with high gross margin.
(e) I don’t have the productive efficiency to the extent required to enter the market of crops with high gross margin.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

The results presented in this table confirm the predictions of the MEFT. That is, the farmer who reached the worse position in Figure 6.2 (farmer a) was the individual who faced more market and resource barriers. According to Table 6.3, farmer a faced land quality restrictions and capital restrictions because this individual responded agreed to the statements (a), (b), and (e). In particular, it can be inferred from the statement (a) that this farmer had a land with a lower quality than the land of farmer b. It can also be inferred from the statements (b) that farmer a faced more capital restrictions than farmer b. These two factors can explain why the former farmer had lower productive capacity than farmer b as inferred from statement (e). According to Table 6.3, farmer a also faced more market barriers than farmer b as inferred from the statements (c) and (d). In particular, it can be inferred from the statement (c) that retailers imposed quantity restrictions that prevented farmer a to access markets with crops with higher levels of gross margin. The statement (d), on the other hand, suggests that lack of innovative capacity was also a barrier that prevented this farmer from adopting crops with higher levels of gross margin.
What is interesting about this example is that the prediction of the MEFT was verified for these farmers: the farmer who faced less market and resources barriers chose a portfolio of crops that allowed him/her to achieve higher levels of expected gross margin and lower levels of business risk simultaneously.

6.2 Phase I of the Static Stage of the Research: General Characteristics of the ESBF

Several empirical studies have revealed that differences in farmers’ individual characteristics such as age, education and training, and differences associated with their farms such as farm size, among others, can also explain differences in farmers’ strategic behaviour (see, for instance, Bergevoet et al., 2004; Willock et al., 1999; and Gasson, 1973). The objective of Phase I was to identify these characteristics for the case of the ESBF and to use them as possible explanatory variables for the regression analyses developed in Phases III of the static stage of the research. The present section also describes the main crops adopted by the farmers in the sample. This information was used to calculate the expected value and the variance of the gross margin of the portfolio of crops chosen by the farmers in the sample.

6.2.1 Characteristics of the ESBF in the sample

The sample used in the research was formed of 47 men and one woman. The average respondent was 52 years old (Standard Deviation SD = 9.98) the oldest being 71 and the youngest 22 years old. According to Figure 6.3 below, the most common age class was composed of farmers aged 50-60 years old.
Even though the most common age class was between 50 and 60 years old, there is also important dispersion around this class. This could constitute an important source of heterogeneous strategic behaviour across farmers (Thenail, 2002). According to Robinson (2000) and Burton (2006), this is because relevant farmers’ objectives change over time according to the phase in the lifecycle of the family-farm and this affects the choice of management strategies (e.g. debt levels, financial sophistication; commitment to farming; contact with agents; risk averseness; farming ideology and attitudes; response to policy; record keeping; size of farming operation; and level of education, among others). This has formally been investigated by Ondersteijn et al. (2003) who found that older farmers were more concerned about expressive goals (i.e. farming is seen as a means of self-expression) such as feed the world and care for a clean environment, and less concerned about instrumental objectives (i.e. farming is viewed as a means of obtaining income) than younger farmers. Because the most common age class in the sample used in the current investigation was composed of farmers aged 50-60 years old (see Figure 6.3), it is expected to find that expressive goals play an
important role in explaining the strategic behaviour of the average respondent. Given the relevance of age as a potential driver of strategic behaviour, age was included as an explicative variable in the regression model presented in Phase III of the static stage of the research.

Regarding formal education and agricultural training, 70.8% of the farmers in the sample reported that they received formal agricultural training in colleges or related institutions, 12.5% had a Bachelor degree in agricultural sciences, and 16.7% did not have any formal training. Formal education and agricultural training were also included as explanatory variables for the regression model developed in Phase III. The reason is that formal education and training might affect farmers’ attitudes towards risk (Knight et al., 2003).

Regarding farm size, Boahene et al. (1999) found that large-scale farmers have more access to bank loans and this strongly increases their opportunities for innovation in response to exogenous shocks in comparison to small-scale farmers. This suggests that farm size could affect farmers’ cropping decisions because innovation can help them to introduce crops with higher levels of gross margin into their portfolios of crops.

Farm size can also affect organisational characteristics of the farm. That is, a large farm would probably have a more complex organisation system having a large number of workers operating in the farm and this, might affect farmers’ capacity to adjust in response to exogenous shocks because complex organisational structures may prevent the diffusion of information that is needed to adjust in turbulent conditions (Van den Bosch et al., 1999). This is why this variable was also included in the regression analysis developed in Phase III. In particular, the data collected in the questionnaire
revealed that the number of workers per farm was 2.4 on average (SD = 2.06) and the average of the farm size in terms of the total area in hectares was 377 (SD = 304.7). A positive relationship between the number of workers and the farm size was identified by means of a linear regression model. The model corresponds to:

\[
W = 0.99 + 0.004\text{AREA} \\
R^2 = 0.32
\]

\[(6.1)\]

\[(2.49)^* (4.67)^{***} (P < 0.05); **(P < 0.01); *** (P < 0.001)\]

where \(W\) denotes the number of workers other than the main manager (i.e. the owner or tenant) and \(\text{AREA}\) is the total area of land per farm in hectares. According to this model, small farms (i.e. farms of less than 100 hectares) had on average of 1 worker working with the principal manager. By contrast, large farms (i.e. Farms of 600-800 hectares) had between 3 to 4 workers working with the principal manager. These workers were composed mainly of family members. Only large farms had hired one or two permanent workers and one or two part time workers. This finding is consistent with the organisational structure of farms described for the UK region. According to Lobley (2010), farmers in this country operate largely as family run businesses.

Finally, regarding farm ownership, 14.6% of the farmers in the sample reported that they were the owners of the farms where they worked, 14.6% were tenants, 54.1% were the owners of a fraction of the farm, and 16.7% did not provide this information. Because a large number of farmers did not report this information, this variable was not included in the regression model presented in Phase III.

6.2.2 Crops chosen by the ESBF
When describing the crops adopted by the ESBF in 2008, it is important to distinguish between crops that were adopted in general, and those adopted to replace sugar beet. This is a relevant distinction because farmers did not produce sugar beet as the unique crop before the closure of the ASBF. For example, some ESBF in the sample also produced wheat. When the factory was closed, some of them maintained the same production of this crop. However, they adopted oilseed rape as a new crop to replace sugar beet and not wheat. Keeping in mind this fact, Section 6.2.2.1 shows the crops that the ESBF adopted in general in year 2008. As pointed out above, some of these crops were not necessarily used to replace sugar beet. However, this information provides a picture of the range of crops adopted by the ESBF in that year. Section 6.2.2.2, in contrast, describes the crops that the farmers in the sample adopted to replace sugar beet.

6.2.2.1. Crops chosen after the SRR

The most important crops chosen by the ESBF in the sample in terms of both area of land covered by these crops and the number of farmers who adopted them were wheat, barley, oilseed rape, oats and potatoes. This information is summarised in Table 6.4.

Table 6.4 Crops chosen by the ESBF in the sample

<table>
<thead>
<tr>
<th>Crop</th>
<th>Number of farmers who adopted this crop</th>
<th>Hectares occupied with this crop</th>
<th>Yield (tons/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>max</td>
<td>min</td>
</tr>
<tr>
<td>Wheat</td>
<td>45</td>
<td>132.3</td>
<td>607.0</td>
</tr>
<tr>
<td>Barley</td>
<td>40</td>
<td>60.7</td>
<td>133.6</td>
</tr>
<tr>
<td>Oilseed Rape</td>
<td>34</td>
<td>64.6</td>
<td>220.0</td>
</tr>
<tr>
<td>Oats</td>
<td>16</td>
<td>41.1</td>
<td>140.0</td>
</tr>
<tr>
<td>Crop</td>
<td>Quantity</td>
<td>Gross Margin (1)</td>
<td>Gross Margin (2)</td>
</tr>
<tr>
<td>--------------</td>
<td>----------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Potatoes</td>
<td>15</td>
<td>47.6</td>
<td>145.0</td>
</tr>
<tr>
<td>Sugar Beet</td>
<td>6</td>
<td>33.3</td>
<td>153.8</td>
</tr>
<tr>
<td>Fodder Beet</td>
<td>6</td>
<td>12.4</td>
<td>22.3</td>
</tr>
<tr>
<td>Maize</td>
<td>5</td>
<td>28.0</td>
<td>80.9</td>
</tr>
<tr>
<td>Beans</td>
<td>3</td>
<td>60.5</td>
<td>95.0</td>
</tr>
<tr>
<td>Peas</td>
<td>3</td>
<td>41.8</td>
<td>89.0</td>
</tr>
<tr>
<td>Rye</td>
<td>3</td>
<td>56.1</td>
<td>126.0</td>
</tr>
<tr>
<td>Carrots</td>
<td>2</td>
<td>8.4</td>
<td>15.0</td>
</tr>
<tr>
<td>Onions</td>
<td>2</td>
<td>8.0</td>
<td>14.2</td>
</tr>
<tr>
<td>Herb Seed</td>
<td>2</td>
<td>50.6</td>
<td>80.9</td>
</tr>
<tr>
<td>Triticale</td>
<td>1</td>
<td>40.5</td>
<td>----</td>
</tr>
<tr>
<td>Parsnips</td>
<td>1</td>
<td>1.8</td>
<td>----</td>
</tr>
<tr>
<td>Strawberries</td>
<td>1</td>
<td>2.7</td>
<td>----</td>
</tr>
<tr>
<td>Raspberries</td>
<td>1</td>
<td>2.7</td>
<td>----</td>
</tr>
<tr>
<td>Turnips</td>
<td>1</td>
<td>7.7</td>
<td>----</td>
</tr>
<tr>
<td>Borage</td>
<td>1</td>
<td>42.5</td>
<td>----</td>
</tr>
</tbody>
</table>

These choices are consistent with the crop patterns in the West Midlands region post SRR (see Tables B.1 and B.2 in Appendix B) in that the farmers specialised in a few traditional crops with low gross margin. This finding suggests that the sample considered in the present study, even though relatively small, reflected the main characteristics of the ESBF in terms of their cropping choices after the closure of the ASBF. Additional information related to prices received by these farmers, intermediaries who bought their crops and the uses for these crops are presented in Appendix Q.

While the objective of this thesis was to investigate farmers’ cropping decisions, it is interesting to notice that some ESBF in the sample were also involved in the production of grassland and livestock, and one in particular was involved in diary production. The development of these activities is associated with a strategic choice. However, given the levels of investment that these activities require, it is reasonable to argue that in the very short-term the ESBF adjusted immediately in response to the closure of the ASBF by modifying the cropping patterns rather than the production levels of livestock and

239
grassland as a way to substitute sugar beet. This is why this thesis focussed on the issue of cropping decisions.

6.2.2.2 Crops chosen to replace sugar beet after the SRR

According to the farmers in the sample, the most important crop used to replace sugar beet after the closure of the ASBF was oilseed rape. The way in which this crop was adopted is explained as follows. The data collected from the questionnaire revealed that 25% of the ESBF in the sample replaced sugar beet exclusively with oilseed rape, and 29.2% of these farmers replaced sugar beet with a set of crops composed mainly of oilseed rape and one or more additional crops such as peas, beans, oats, wheat, barley, maize, rye, fodder beet or grass seed. The rest of the participants replaced sugar beet with oats (6.3%), maize (4.2%) or a combination of crops formed of oats with barley, wheat or potatoes (18.8%), among others. A small fraction of the farmers rented the land that they used to cover with sugar beet (4.2%). Finally, the rest of the farmers (12.3%) did not answer this question. These statistics are shown in Figure 6.4.
This figure shows that about 54% of the farmers adopted oilseed rape to replace sugar beet either as a single crop or accompanied by other crops such as wheat and barley, among others. This result supports the suggestion made by Clothier (2010) and Department for Environment Food and Rural Affairs (2010a) stating that these crops were used to replace sugar beet. On the other hand, it is interesting to notice that oats was lowly adopted by the farmers in the sample. In particular, Figure 6.4 shows that only 6.3% of the farmers in the sample adopted oats as a single crop to replace sugar beet, and only 18.9% of the farmers in the sample adopted oats accompanied by other crops such as wheat and barley or potatoes to replace sugar beet. Finally, other less relevant choices were maize and rented land.

It is important to highlight the fact that while most of the farmers in the sample adopted crops with low gross margin to replace sugar beet, some of them also introduced some crops with relative high gross margin such potatoes, beans and peas. The main
implication of this finding is that the initial hypothesis used in this thesis establishing that all the ESBF replaced sugar beet with crops with low gross margin is not fully supported. However, crops with relatively high gross margin were always introduced with crops with low gross margin (mainly oilseed rape) and in low proportions with respect to the latter implying that a large fraction of crops with low gross margin were indeed used to replace sugar beet.

6.3 Phase II of the Static Stage of the Research: Dynamic Capabilities

The objective of Phase II was to determine whether the ESBF had the ability to develop dynamic capabilities (DC) after the closure of the ASBF. Before presenting the results obtained in this phase, however, it is important to bear in mind some important concepts that were considered in the literature review developed in Section 3.2.2. Firstly, DC is defined by Eisenhardt and Martin (2000) as the ability to integrate, reconfigure, gain and release resources in response to environmental changes in order to reach and sustain competitive advantage. Therefore, determining whether the ESBF had the ability to develop DC is equivalent to determining whether these individuals had the ability to integrate, reconfigure, gain and release resources in response to the closure of the ASBF to reach and sustain competitive advantage. Secondly, DC are characterised by three components or factors that are common across firms (Wang and Ahmed, 2007): adaptive capability (AC); absorptive capability (ABC); and innovative capability (IC). This implies that any driver that contributes in the development of one of these components does also contribute in the development of DC. Consequently, because several drivers of AC, ABC and IC were identified in Section 3.2.2, they were considered as potential drivers of DC for the case of the ESBF studied in Phase II of the research.
The analysis of DC used in Phase II of the research was organised as follows. Section 6.3.1 examines each of the determinants of AC, ABC and IC that were identified in Section 3.2.2 with the purpose of determining whether the ESBF in the sample had the capacity to develop DC when the ASBF was closed. Section 6.3.2, on the other hand concludes the analysis of DC.

6.3.1 Analysis of the Determinants of DC for the ESBF in the Sample

According to discussion on DC developed in Section 3.2.2, organisational structures help firms to develop both adaptive capability (AC) and absorptive capability (ABC) (Tushman and O’Reilly, 1996; Van den Bosch et al., 1998; and Moon et al., 2004). In particular, there are two main reasons why organisational structures can help firms to develop AC. Firstly, some structures favour the flow of relevant information that is needed to identify emerging market opportunities. According to Labovitz (1971), the flow of this information is favoured in turbulent conditions when people work in a more informal environment. The author argued that highly differentiated organisations with well established roles are not flexible enough to permit firms to obtain relevant information at the speed needed to adjust in dynamic market conditions. Secondly, some structures allow firms to quickly adjust in response to emerging market opportunities. In this context, Moon et al. (2004) explained that groups should be structured according to functional departmentation (i.e. grouping is based on the similarity of the work people perform) when operating in stable and predictable environments. In contrast, they should be structured according to divisional departmentation (i.e. grouping is based on either the type of product they produce or the geographic region they serve) when the business environment is turbulent. This is because these environments are associated
with changing and complex contingencies that poorly match the specialised skills of individual that are members of a team. Organisational structures can also help organisations to develop ABC because some structures favour the absorption of relevant knowledge in turbulent business environments. For example, Van den Bosch et al. (1999) argued that functional organisations have high potential for efficiency, but have low flexibility for knowledge absorption. In contrast, a divisional form have low potential for efficiency, but high flexibility for knowledge absorption making this organisation more suitable for unstable business environments.

In the case of the ESBF, these farmers own family run firms composed of three individuals on average (see Section 6.2.1): the principal farmer (owner or manager) and two workers. The survey revealed that the organisational structure of this reduced number of individuals is neither functional nor divisional. This is a consequence of the reduced number of individuals working in the farm. Nonetheless, workers have to complete specific tasks such as machine work, among others; and managers have to complete, in addition, specific tasks such as finance and administration. Working under this scheme that is characterised by the existence of individuals specialised in specific tasks could not have the flexibility needed to match the contingences arising in turbulent conditions. This is why it was argued in this thesis that the organisational structure of the ESBF did not contribute to the development of DC after the closure of the ASBF.

Quantity of resources is another determinant of DC because it affects the development of AC and IC (Chakravarthy, 1982; and Branzei and Vertinsky 2006). According to McCann and Selsky (1984), AC can be developed when individuals have the skills to maintain the viability of the business by managing resources that are abundant and varied. Since it was found that the ESBF in the sample had relatively few resources
suitable only for the production of traditional crops, it was concluded that these farmers had few opportunities to develop AC. This is one of the reasons explaining why most of them had specialised in crops with low gross margin such as oilseed, among others. According to these individuals, they were unable to increase the number of resources because they faced capital restrictions. Since the production of more innovative crops with high levels of gross margin requires specific and expensive machinery, investing in this machinery was not an option for them.

Contextual ambidexterity refers to the ability to develop simultaneously two different types of activities (Gibson and Birkinshaw, 2004): one with the purpose of improving performance in the short run; and the other with the objective of improving performance in the long run. The reason that contextual ambidexterity contributes to the development of AC is because it allows firms to capitalise on emerging market opportunities without affecting performance in the short run. For example, suppose that a farmer identifies a market opportunity consisting of producing apples. Capitalising on this opportunity could negatively affect performance in the short run because this business only produces revenue when the trees of apple have grown enough (approximately three years after the trees are established in the field). This delay in production could eventually prevent the farmer from investing in this business. However, contextual ambidexterity could help this farmer to maintain performance by developing two activities: producing traditional crops to maintain performance in the short run; and capitalising in the production of apples to maintain performance in the long run.

In terms of the ESBF in the sample, the results revealed that most of these individuals did not develop activities to maintain performance in the long run. According to the results, this is because these farmers faced important market barriers that prevented
them from expanding the business by incorporating crops with higher levels of gross margin. This was determined from the following analysis. Farmers were asked to respond the following question: “Which of the following barriers prevented you from choosing other crops with higher levels of gross margin (such as carrots and parsnips for example)?” The following 5-point Likert scale was used to answer the question: strongly disagree = 1; disagree = 2; indifferent = 3; agree = 4; and strongly agree = 5. Table 6.5 summarises the results showing the average of the scores assigned by the participants to each statement and the associated standard deviation:

Table 6.5 Barriers that prevent farmers from choosing crops with higher gross margin.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Average</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) The markets for these crops are very selective</td>
<td>4.23</td>
<td>0.60</td>
</tr>
<tr>
<td>b) I am not interested in producing other crops with high gross margin</td>
<td>2.46</td>
<td>1.22</td>
</tr>
<tr>
<td>c) My land is not appropriate to produce these crops</td>
<td>2.69</td>
<td>1.22</td>
</tr>
<tr>
<td>d) I don’t have the necessary capital and machinery to produce them</td>
<td>3.42</td>
<td>1.07</td>
</tr>
<tr>
<td>e) Retailers demand quality that it is difficult to achieve</td>
<td>4.00</td>
<td>0.75</td>
</tr>
<tr>
<td>f) Retailers demand a volume that I cannot produce</td>
<td>3.34</td>
<td>1.07</td>
</tr>
<tr>
<td>g) Retailers have too much negotiation power</td>
<td>4.44</td>
<td>0.68</td>
</tr>
<tr>
<td>h) Producing these crops implies collaborative alliances that are difficult to form</td>
<td>3.54</td>
<td>0.97</td>
</tr>
<tr>
<td>i) I am not able to innovate to the extent required to enter the market</td>
<td>2.85</td>
<td>0.92</td>
</tr>
<tr>
<td>j) I don’t have the productive efficiency to the extent required to enter the market</td>
<td>3.15</td>
<td>1.01</td>
</tr>
</tbody>
</table>

This table reveals that farmers, on average, disagreed with the statement “I am not interested in producing other crops with high gross margin”. This implies that these individuals were interested in producing crops with high gross margin that could have contributed to maintaining performance in the long run. However, the existence of market barriers in agriculture prevented them from producing these crops. Table 6.5 shows that the most important barriers identified in this study were: high negotiation power of retailers; high quality that these agents demanded; and high degree of selectivity of these markets. The existence of these barriers suggests that most of the farmers in the sample were prevented from developing AC by means of contextual ambidexterity.
Another determinant of DC identified in Section 3.2.2 corresponds to managerial capabilities and they help firms to develop both AC and IC (Chakravarthy, 1982; and Macpherson et al., 2004). This is because resources that are abundant and varied can only be used to sustain competitive advantage in dynamic environments when they are managed appropriately. Because most of the ESBF in the sample had few resources that were specific to the production of traditional crops, it was concluded that they had not developed the capabilities needed to manage a more complex set of resources.

Pre-existing knowledge of market trends and productive processes has also been identified as determinants of DC because they help the development of ABC. According to Cohen and Levinthal (1990), this is because the ability to recognise the value of new external information that is needed for commercial ends is a function of the richness of the pre-existing knowledge structure. The authors argued that if the subject of learning is already known, then the learning performance is greater. In order to determine whether the farmers in the sample had pre-existing knowledge of market trends and productive processes, two indicators were employed: (i) one indicator to determine pre-existing knowledge of market trends (IMT); and (ii) one indicator to determine pre-existing knowledge of productive processes (IPP). The IMT considered farmers’ knowledge of policy trends as a proxy of pre-existing knowledge of market trends. This was because markets are strongly affected by policy changes. For this purpose, these farmers were asked to use a 5-point Likert scale in the following statement “I consider government policy unpredictable”. The participants’ response when considered as an average was 4.31 (SD = 0.88) meaning that on average they agreed with the statement. Regarding IPP, on the other hand, the farmers in the sample were asked to use a 5-point Likert scale in the following statement “I am not familiar with the productive process of
crops with higher levels of gross margin”. These farmers assigned on average a value of 3.5 meaning that on average they agreed with this statement. These results indicate that the ESBF in the sample did not have pre-existing knowledge of both market trends and productive processes crops with high gross margin. As a consequence, it was concluded that the ESBF did not have the pre-existing knowledge needed to contribute in the development of DC.

Diversity of knowledge is also a determinant of DC because it contributes to the development of ABC. This is because Individuals with a varied background tend to find it easier to accept new information for commercial ends and to marry it their existing experience and knowledge base (Cohen and Levinthal, 1990). For example, suppose that a farmer is interested in expanding the business by producing dried grains of wheat. If a worker of the farm used to work before in drying grains of barley, this knowledge can facilitate the expansion of the business. This is because it is easier to match the new information associated with the commercial production of dried grains of wheat with existing knowledge related to dried grains of barley. Nonetheless, it is important to highlight the fact that diversity of knowledge can only contribute to the development of ABC when this knowledge is available for all the members of the organisation, i.e. when the knowledge is well distributed across the members of the organisation. In fact, ABC can be negatively affected when an area of knowledge is possessed only by a fraction of the members. This is why distribution of knowledge has also been identified as a determinant of ABC (Cohen and Levinthal, 1990). In the example, if the farmer does not inform the workers about his intention to expand the business, then he will probably not be able to identify and capitalise upon existing knowledge regarding dried grains of barley possessed by one of the workers. This lack of communication and odd distribution of pre-existing knowledge might even negatively affect the expansion of the
business in that, for example, the farmer might decide not to expand the business if the
information regarding the productive process of dried grains of wheat was expensive
and difficult to obtain.

In the case of the ESBF in the sample, the results revealed that most of the interviewees
did not have diversity of knowledge because their knowledge was limited on narrow
topics associated with their current productive activities of traditional crops. However,
this narrow knowledge was well distributed across workers because most of these
individuals were specialised in the production of traditional crops. This is also
supported from the finding described previously: the farmers in the sample did not have
a pre-existing knowledge of both market trends and productive processes of alternative
crops with high levels of gross margin. The exception was found in a reduced number
of farmers in the sample who had sons studying a Bachelor Degree in Agricultural
Science. It is possible that these individuals will benefit from this source of diversity of
knowledge because this academic knowledge could be used to deal with new
information associated with market opportunities. Apart from these isolated cases, it
was concluded that the farmers in the sample were in general unable to take advantage
of diversity of knowledge as a way to facilitate the processing of new information for
commercial ends. In addition, distribution of information seemed not to be relevant in
helping the ESBF to develop ABC. This is because even when the exiting knowledge
was well distributed across workers in the farms, this knowledge was confined to
narrow topics related to current productive activities that were not linked to potential
market opportunities.

Another determinant of DC is self-motivation because it also contributes to the
development of ABC (Cohen and Levinthal, 1990). In order to understand this, it is
necessary to remember that ABC was defined as the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends in order to innovate. If a farmer does not have self-motivation, then even when being able to recognise the value of new external information he will probably not use it for commercial ends. A good example of this was found in the current investigation. Some farmers in the sample stated that they knew that the production of carrots provides high levels of gross margin. They also thought it would be possible for them to easily learn how to produce this crop because they had the capacity to assimilate this information. However, they were not interested in developing this business because the production of carrots is very time demanding and they preferred to have free time. This example suggests that self-motivation depends on farmers’ goals. Because goals are intrinsic characteristic of farmers (i.e. farmers are who define their goals), it was concluded self-motivation was an available determinant of DC for the ESBF.

As discussed in Section 3.2.2, good communication across members of the organisation is another determinant of DC because this helps firms to develop both ABC and IC (Johnson et al., 2001; and Lenox and King, 2004). In the case of ABC, good communication among members helps the diffusion of new information than can be used for commercial ends. According to Lenox and King (2004), this transfer of information can help the organisation to reduce the search costs of new practices and to increase the likelihood of adoption. For example, suppose that a worker identifies an alternative more efficient and cheaper technology to produce traditional crops. This worker could then inform the members of the farm about this technology with the objective of gaining competitive advantage. However, if communication across members is poor, then this knowledge could not be diffused and, as a result, could not be used for commercial ends. Lenox and King (2004) argued that good communication
can be reached by means of the adoption of some strategies such as internal seminars, demonstrations, and promotional brochures. Good communication, on the other hand, can also help firms to develop IC because it facilitates the alignment of strategic orientation with the purpose of developing new products and/or markets. In particular, good communication (i.e. communication quality and interpersonal communication) increases individuals’ involvedness in innovation processes and this facilitates the adoption of a strategic orientation of the firm that is needed to innovate (Johnson et al., 2001).

In the case of the ESBF, lack of communication among members of the farm was probably not an issue given the small number of individuals operating in the farm (the results obtained in Phase I of the research revealed that this number is on average equal to three: the principal manager or owner of the farm and two workers). That is, bad communication is probably more common in large organisations because the diffusion of relevant information requires a greater level of interpersonal relations in order to reach all the members. This suggests that communication was an available determinant of DC for the ESBF.

Strategic alliances play an important role in helping firms to develop ABC and IC (Lane and Lubatkin, 1998; Hagedoorn and Duysters, 2002; and Chen, 2004). As a consequence, they also are drivers of DC (see the discussion on DC presented in Section 3.2.2). They contribute to the development of ABC and IC because they open channels that can be used to recognise new information that could be used for either commercial ends or innovative activities (Chen, 2004). In particular, strategic alliances help organisations to increase negotiation power. The latter, in turn, helps farmers to access different markets that provide information that could eventually be used for commercial
ends and innovation. In order to identify farmers’ attitudes towards the formation of these alliances, they were asked to use a 5-point Likert scale in the following statement: (Forming) “collaborative alliances to increase negotiation power is a suitable business strategy to make my farm a successful business enterprise”. The average score on this item was 3.60 with an SD of 1.05. This means that these farmers had a positive attitude towards collaborative alliances as tools to increase negotiation power. However, the results also revealed that only few of the farmers in the sample were involved in collaboration. This result is surprising. Why did farmers who believed that the formation of strategic alliances was a beneficial practice not actually become involved in these alliances? According to the farmers, the reason is because they didn’t trust their potential partners. They argued that if they were able to formally define property rights among members of the alliance, then they would be willing to form these alliances. The distrust problem has also been identified by related studies (see, for instance, Gerichhausen et al., 2009; and Banaskar, 2008). Because distrust is an important factor limiting the formation of strategic alliances in agriculture, it was concluded that the ESBF were unable to increase their ability to develop DC by means of these alliances.

Participation in social networks is also a determinant of DC because they help firms to develop ABC and IC (Boahene et al., 1999; Chang, 2003; Chen, 2004; and Macpherson et al., 2004). This is because links constitute informational channels for new information that could be used for commercial ends and innovation. This is why participation in formal and informal networks has been identified as an important driver of innovation rural areas (Virkkala, 2007; and Boahene et al., 1999). In order to identify whether this determinant of DC was available for the ESBF included in the sample, respondents were asked to indicate whether they participated in networks in the free and contract markets. The results revealed that 54.2% of these individuals participated in
networks in the free market; 37.5% did not participate in networks in this market; and 8.3% did not respond to the question. The results also revealed that 62.5% of the farmers in the sample participated in networks in the contract market; 29.2% did not participate in this market; and 8.3% did not respond to the question.

These results indicate that participation in social networks was a common practice for the ESBF. Moreover, farmers who reported that they were not involved in these networks said that it was not difficult to participate in them, at least in the free market as this market was open to anyone. These individuals did not explain why they were not involved in networks even when this choice was available. Even so, this result suggests that participation in networks was available as a choice in rural areas. As a consequence, it was concluded that this driver could have helped the ESBF to increase their ability to develop DC.

Combinative capabilities refer to the ability to combine or integrate the individual capabilities of the members of an organisation in order to generate new applications from existing knowledge (Kogut and Zander, 1992). Combinative capabilities are determinants of DC because they contribute to the development of ABC as new applications from existing knowledge can be used for commercial ends (Van den Bosch et al., 1998).

This can be illustrated through, the example of the farmer who is interested in expanding the business by incorporating the production of dried grains of wheat. The experience of one of the workers in the production of dried grains of barley, means that there is existing knowledge which could be adapted for wheat. The new application of this existing knowledge requires, however, combining the individual capabilities of the
members of the farm in order to adapt this technology for the production of dried grains of wheat. In the case of the ESBF, it seems to be the case that this determinant of DC was not available to these individuals when the ASBF was closed. This is because the existing knowledge of the farm was used in closely related applications associated with the production of traditional crops in response to the closure of the ASBF. As stated by the farmers in the sample, traditional crops require in general the same machinery and productive processes. Therefore, because the ESBF produced a portfolio of crops formed of sugar beet and traditional crops such as wheat and barley, the replacement of sugar beet with oilseed rape and oats (i.e. other traditional crops) did not reflect a new application of existing knowledge.

Another driver of DC is technical and market experience because this helps firms to develop IC in the form of incremental production innovation (Zinger, 1997). In other words, technical and market experience helps firms to improve the performance of existing products. According to Zinger (1997), this is because this experience strengthens core competences, reduces production costs as a consequence of learning by doing, and reduces innovation time when this experience if focussed on incremental product changes.

Regarding the case of the ESBF, this determinant of DC was available for these farmers because they had technical and market experience related to the production of traditional crops. This can explain why they replaced sugar beet with other traditional crops: they had core competences in the production of these crops, and they also were able to reduce production costs because they already learned through practice how to produce these crops. This suggests, therefore, that the choice of adopting new traditional
crops in response to the closure of the ASBF was a defender strategy consistent with the core competence and experience of these farmers.

Another important determinant of DC is regulatory environment because it can affect firms’ ability to develop IC (Delmas, 2002). For example, a regulatory environment characterised by the existence of formal intellectual property rights stimulates innovation as this permits firms to improve their competitive position from their innovative activities. According to Dwyer et al. (2007), the regulatory environment in agriculture after the implementation of the CAP reform Agenda 2000 was not appropriate to develop innovation. This is because the CAP remains a centralised and hierarchical approach in terms of programme audit and control within the EU’s administrative apparatus. This centralisation, in turn, has translated into a continuing institutional inertia within the public administration. Dwyer et al. (2007) argued that this institutional inertia prevents the effective application of programmes of development introduced by recent CAP reforms. This finding suggests that the institutional inertia of the CAP was not appropriate to help the ESBF to develop IC.

Finally, attitude toward risk has also been identified as another relevant determinant of IC. For example, Delmas (2002) found that risk averse individuals were less willing to innovate than risk neutral or risk lover agents because innovation has a degree of uncertainty. The regression analysis presented in Section 6.4.1 revealed that the farmers in the sample were all risk averse. This finding suggests, therefore, that attitudes towards risk did not favour the development of DC for the case of the ESBF in the sample.
6.3.2 Concluding the Analysis of DC

According to the analysis conducted in the last section, the ESBF had low capacity to develop DC because only few drivers of DC were available for these farmers. This result explains why these individuals replaced sugar beet with crops with low gross margin (mainly oilseed rape and oats). This is illustrated by the fact that the limited number of usable drivers of DC for the ESBF only helped these individuals to maintain their share in the market of traditional crops. That is, these drivers only allowed these farmers to adopt a defender strategy under the Miles and Snow’s typology. The available drivers for the ESBF correspond to self-motivation, technical and market experience, communication, and participation in networks.

Self-motivation favoured the defender strategy because farmers in general were not interested in adopting crops with high gross margin as they are time demanding. In other words, they were motivated in developing productive activities that allowed them to enjoy more free time. Regarding technical and market experience, most ESBF had technical and market experience associated with the production of traditional crops. This suggests, therefore, that these individuals had core competences in the production of these crops. As a consequence, adopting a defender strategy was the optimal choice for the ESBF given their knowledge of traditional crops, their core competences in the production of these crops, and the barriers preventing them from adopting crops with higher levels of gross margin. Communication was also an available driver of DC because lack of communication among members of the farm was probably not an issue given the small number of individuals operating in the farm. As explained above, bad communication is probably more common in large organisations because the diffusion of relevant information requires a greater level of interpersonal relations in order to
reach all the members. However, communication did not play a role in helping farmers
to diversity into crops with high gross margin. A possible explanation is that members
of the farm only shared information related to the production and market of traditional
crops because they had core competences in the production of these crops. That is,
communication could have favoured the diffusion of information related to traditional
crops because farm managers probably cared about sustaining competitive advantage in
the market of these crops, at least in the short run. Finally, participation in networks was
also an available driver of DC for the ESBF. According to the results, a significant
number of these farmers participated in networks either in the free market or in the
contract market. Apparently the ESBF farmers used these networks to strength their
links with the market of traditional crops rather than to obtain information related to
crops with high gross margin. This can explain why these individuals had more links
with intermediaries of traditional crops as shown in Table Q.2 in Appendix Q.

By contrast, the drivers that were not available for the ESBF are more suited to
exploiting new product and market opportunities. Thus, if these drivers were available
for the ESBF, then these individuals would have probably adopted a prospector strategy
in response to the closure of the ASBF (this possibility is formally studied in Chapter
Seven). To exemplify this, suppose that a farmer had abundant quantity of resources
such as capital, pre-existing knowledge of market and the production processes of crops
with high levels of gross margin, and was able to form strategic alliances that permitted
him to enter in exclusive markets for these crops. These determinants could have
allowed this farmer to adjust in the turbulent conditions by achieving competitive
advantages in markets of crops with high levels of gross margin.
In summary, the ESBF were businesses with high levels of inertia, and this reflects the fact that these individuals had few available drivers of DC when the SRR was implemented. This explains why these individuals adopted a defender strategy in response to the closure of the ASBF.

This leads to the question of whether these individuals were identical in terms of the strategy that they adopted in response to the closure of the ASBF. According to the Multiple Efficient Frontiers Theory (MEFT) developed in this thesis, defender farmers can still adopt different strategies by changing the proportion of crops used in their portfolios in order to reach desirable levels of expected gross margin and business risk. These differences, in turn, can reflect the existence of asymmetries across these individuals such as different quality of land, different farmers’ goals, different market barriers, etc. This is the topic analysed in the next section.

6.4 Phase III of the Research: Strategic Behaviour in Stable Business Environments

The results presented in the last section showed that the ESBF had few opportunities to develop DC. In fact, they had only a reduced number of determinants of DC and this explains why these farmers adjusted to the closure of the ASBF by adopting crops with low gross margin. In particular, it seems to be the case that they had core competences in the production of these traditional crops. As a consequence, adopting a defender strategy in order to maintain their share in these markets was an optimal choice for them.
It is important to clarify, however, that lack of opportunity to develop DC is only one of the possible reasons explaining the cropping choices made by the ESBF in response to the SRR. As shown in the literature review developed in Chapter Three, there are different complementary approaches that can also explain this choice: multiple goals approach; utilitarian approach; theory of planned behaviour; and market and resources barriers (see Figure 6.1). It is possible that the cropping choices made by the ESBF were influenced by all these approaches simultaneously. For example, suppose that there are two farmers who produce wheat and barley. Suppose in addition that one of them decided to establish 80 hectares of wheat and 20 hectares of barley, and the other decided to establish 35 hectares of wheat and 65 hectares of barley. The analysis of DC developed in the last section can be used to identify why these individuals chose these crops with low gross margin: these farmers chose these crops because they were not able to develop DC. However, it cannot explain why these farmers produced these crops in different proportions.

As explained in Chapter Four, the proposed multivariate model and the MEFT developed in this thesis fills this gap because they consider a holistic perspective of farmers’ strategic behaviour that not only includes dynamic capability, but also other non-economic drivers. Moreover, testable behavioural predictions were inferred from these developments and they were formalised in a number of hypotheses. The objective of Phase III was to test some of these hypotheses with the purpose of identifying the relevant variables (economic and non-economic drivers affected) that explained farmers’ cropping decisions.

6.4.1 Testing the HRA and the HSCRA using an experimental method
Following Step 1 of the statistical analysis described in Section 5.3.4.3, the Equation 5.7 was estimated using linear regression using data collected from Question 9 of the questionnaire (see Appendix L). This equation is presented in this section again as follows:

\[
U_{ik} = \beta_0 + \beta_1 \pi_{ik} + \beta_2 V_{ik} + \sum_i \beta_i D_i V_{ik}
\]  

(6.2)

where \( U_{ik} \) represents the preference ranking score assigned by farmer \( i \) to crop \( k \) (for example, if a farmer assigned a value equal to 7 to carrots and 5 to potatoes, then carrots were preferred by this individual); \( \pi_{ik} \) represents the gross margin ranking score assigned by farm \( i \) to crop \( k \) (for example, if a farmer assigned a value equal to 5 to carrots and 3 to potatoes, then according to this farmer carrots have higher level of gross margin than potatoes); \( V_{ik} \) represents the business risk ranking score assigned by farm \( i \) to crop \( k \) (for example, if a farmer assigned a value equal to 5 to carrots and 4 to potatoes, then according to this farmer carrots are riskier than potatoes); \( \beta_0, \beta_1, \beta_2 \) and \( \beta_i \) are the regression coefficients, and \( D_i \) is the multiplicative dummy assigned to farmer \( i \). Note that the slope of the variable \( V_{ik} \) represents the coefficient of absolute risk aversion (a formal explanation is given in Step 1 of Section 5.3.4.3).

As explained in detail in Step 1 of Point (b) in Section 5.3.4.3 and in Appendix P, the utility presented in Equation 6.2 corresponds to an ordinal concept that is used by modern economic theory. That is, it describes farmers’ preferences rather than farmers’ level of satisfaction. This is formally pointed out by Eaton et al. (1999): “These observations should make it clear that the economist’s theory of utility is a theory of ordinal utility, not cardinal utility. Utility numbers reveal only the relative ordering of
consumption bundles (first, second, or third) and nothing about the distance between bundles in terms of desirability (twice as desirable or one-third as desirable)” (p. 62).

The main implication of this concept is, as explained in detail in Section 5.3.4.3, that any scale can be used to represent utility preferences as long as they are linked to preferences. In this experimental method, a simple scale was adopted which links an integer number to the available options.

It is important to keep in mind that the main disadvantage of this approach is that it does not consider how desirable the available options for individuals are. For example, wheat could be twice as desirable as barley for a farmer and only on-third for another individual. However, because it is difficult to record levels of desirability, the ordinal approach can be considered as a second best to investigate farmers’ preferences on the selected choices.

On the other hand, the objective of introducing dummy variables is to capture differences in this slope across the farmers in the sample with the purpose of measuring differences in attitudes towards risk. For example, suppose for simplicity that there are only two farmers: Farmer A; and Farmer B (i.e. the index $i$ in Equation 6.2 can be equal to A or B depending on the farmer under consideration). In this case the model presented in Equation 6.2 converges to:

$$U_{ik} = \beta_0 + \beta V_{1ik} + \beta V_{2ik} + \beta A D A V_{ik} + \beta B D B V_{ik}$$

(6.3)
Suppose that after running this regression, it is found that only the coefficients $\beta_0$, $\beta_1$, $\beta_2$, and $\beta_A$ were statistically significant, and $\beta_B$ was not significant. This implies that the model presented in Equation 6.3 can be represented as:

$$V_{ik} = \beta_0 + \beta_1 \pi_{ik} + \beta_2 V_{ik} + \beta_A D_A V_{ik}$$ \hspace{1cm} (6.4)

Now, because the dummy variable $D_A$ takes a value equal to 1 when this equation considers Farmer A (i.e. when $i = A$) and zero when this equation considers Farmer B (i.e. $i = B$), it is possible to obtain two equations from Expression 6.4: one for each farmer. These equations are presented as follows:

$$U_{Ak} = \beta_0 + \beta_1 \pi_{Ak} + \beta_2 V_{Ak} + \beta_A V_{ik} = \beta_0 + \beta_1 \pi_{Ak} + (\beta_2 + \beta_A) V_{Ak}$$ \hspace{1cm} (6.5)

$$U_{Bk} = \beta_0 + \beta_1 \pi_{Bk} + \beta_2 V_{Bk}$$ \hspace{1cm} (6.6)

The only difference between these two expressions is that the slope of the variable $V_{ik}$ for Farmer A is $(\beta_2 + \beta_A)$, and for Farmer B is $\beta_2$. This example shows the advantage of using multiplicative dummy variables. They permit capturing different slopes for the variable $V_{ik}$ which implies different attitudes toward risk between Farmers A and B.

The experimental method adopted to test the HRA and the HSCRA was modified because some farmers only responded partially to Question 9 of the questionnaire (see Appendix L). That is, a significant number of farmers considered only the crops listed
in this question that they were familiar with. As a result, the experiment only considered the following crops: wheat; barley; oilseed rape; and oats. In addition, one farmer was eliminated because this individual did not respond to Question 9 properly. Because 47 farmers and 4 crops were included in the experiment, it was possible to obtain $47 \times 4 = 188$ observations from this sub-sample. The farmer who was omitted from this subset corresponded to observations 1. In order to determine whether the coefficient estimated by the model were unbiased, two econometric tests were conducted (see Section 5.4.6 for a formal description of these tests): the Jarque-Bera test of normality; and the White Heteroskedasticity test. The Jarque-Bera test had a value equal to 0.23 ($p = 0.89$). As a consequence, the null hypothesis establishing that the residuals come from a normal distribution was not rejected. The White Heteroskedasticity test, on the other hand, had a value equal to 0.92 ($p = 0.65$). As a consequence, the null hypothesis establishing that the variance of the residual term is homoskedastic was not rejected. The results provided by these tests suggest, therefore, that the coefficients estimated by the model were unbiased and reliable. The regression is presented in Table 6.6.
Table 6.6: Regression results. Dependant variable: preference ranking score assigned by farmer $i$ to crop $k$ ($U_{ik}$).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient $(n = 188)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.09*** (6.03)</td>
</tr>
<tr>
<td>Gross margin ranking score ($\pi_{ik}$)</td>
<td>0.55*** (7.82)</td>
</tr>
<tr>
<td>Business risk ranking score ($V_{ik}$)</td>
<td>-0.55*** (-2.67)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 2</td>
<td>0.15 (0.54)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 3</td>
<td>-0.25 (-0.56)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 4</td>
<td>0.18 (0.72)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 5</td>
<td>0.07 (0.23)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 6</td>
<td>0.04 (0.13)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 7</td>
<td>0.16 (0.61)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 8</td>
<td>0.07 (0.23)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 9</td>
<td>0.19 (0.75)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 10</td>
<td>0.01 (0.04)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 11</td>
<td>0.12 (0.44)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 12</td>
<td>0.13 (0.46)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 13</td>
<td>0.07 (0.23)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 14</td>
<td>0.10 (0.36)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 15</td>
<td>0.07 (0.23)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 16</td>
<td>0.18 (0.63)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 17</td>
<td>0.08 (0.29)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 18</td>
<td>0.33 (1.46)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 19</td>
<td>0.11 (0.38)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 20</td>
<td>0.07 (0.23)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 21</td>
<td>0.16 (0.72)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 22</td>
<td>0.27 (1.13)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 23</td>
<td>0.15 (0.54)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 24</td>
<td>0.07 (0.23)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 25</td>
<td>0.05 (1.12)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 26</td>
<td>0.11 (0.31)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 27</td>
<td>0.12 (0.47)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 28</td>
<td>0.20 (0.71)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 29</td>
<td>0.18 (0.73)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 30</td>
<td>0.26 (1.48)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 31</td>
<td>0.16 (0.63)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 32</td>
<td>0.24 (1.06)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 33</td>
<td>0.07 (0.23)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 34</td>
<td>0.15 (0.56)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 35</td>
<td>0.17 (0.61)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 36</td>
<td>-0.39 (-0.89)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 37</td>
<td>0.05 (0.16)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 38</td>
<td>0.20 (0.76)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 39</td>
<td>-0.03 (-0.08)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 40</td>
<td>0.23 (0.97)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 41</td>
<td>0.17 (0.68)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 42</td>
<td>0.27 (1.18)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 43</td>
<td>0.07 (0.23)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 44</td>
<td>0.17 (0.61)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 45</td>
<td>0.17 (0.25)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 46</td>
<td>0.05 (0.19)</td>
</tr>
<tr>
<td>Multiplicative dummy variable for farmer 47</td>
<td>0.08 (0.27)</td>
</tr>
</tbody>
</table>

$R^2 = 0.35$
This table shows that none of the multiplicative dummies was significant. This means that the ESBF included in the experiment had the same attitudes towards risk. In other words, this means that they have the same coefficient of absolute risk aversion according to equation 6.2 (this concept is formally defined in Section 3.3.2.1 and Appendix D). As a result, the HSCRA was not rejected.

This finding is interesting because this explains why these farmers adjusted to the closure of the ASBF by choosing the same crops with low gross margin. To illustrate this, let us consider the following example. Suppose that there were two alternative crops to replace sugar beet: Crop A which had high level of business risk; and Crop B which had low level of business risk. If two farmers had the same attitudes towards risk, then it would be expected to find either that both of them chose Crop A, or both of the chose Crop B. However, it would be counterintuitive to find a case in which one farmer chose Crop A and the other Crop B as these crops have different levels of business risk. Note that this similar choice cannot be explained by lack of opportunities to develop DC. As shown in Section 6.3, lack of opportunity to develop DC can explain why farmers chose crops with low gross margin to replace sugar beet, but not why farmers chose the same crops to replace sugar beet. The result obtained in this section, therefore, extends the analysis of DC in the context of farmers’ cropping decisions.

An important question arising from this result is why farmers had the same attitudes towards risk. As shown in the literature review developed in Chapter Three, this result could be explained by the institutional theory. According to this theory, individuals perceive the world subjectively and this perception is influenced by social norms, social
prescriptions and collective beliefs. When these social norms and beliefs are taken for
granted (i.e. when they are institutionalised) individuals behave accordingly. This
theory postulates that relatively similar organisations adopt similar practices when
norms become accepted unquestioningly. In the case of the ESBF, this suggests that the
ESBF had the same attitudes towards risk because they took for granted certain
common social norms, social prescriptions and collective beliefs that were probably
present in the rural world. That is, they probably had the same understanding of these
norms, prescriptions and beliefs. Unfortunately, it was not possible to confirm this
possibility because information about social norms and beliefs in the rural world of the
West Midlands region is not available in the public domain. Nonetheless, the study of
the link between attitudes toward risk and social norms constitutes a possible extension
for future research.

On the other hand, the regression presented in Table 6.6 shows that the coefficients of
the variables gross margin ranking score ($\pi_{ik}$) and market risk ranking score ($V_{ik}$) were
positive and negative, respectively, as was expected. That is, farmers preferred crops
achieving higher levels of gross margin and lower levels of business risk. This means
that the ESBF in the sample were all risk averse. As a consequence, the HRA was not
rejected. This result offers an alternative point of view regarding why farmers did not
adopt crops with higher levels of gross margin. As shown in Table 3.2 in Chapter Three,
these crops are also riskier enterprises. It is not surprising then that risk averse farmers
adjusted to the closure of the ASBF by choosing crops with low gross margin.

6.4.2 Testing the HOP by estimating the \textit{EPL}
As explained in Section 4.3.1 and in Appendix H, the MEFT proposed in this thesis predicts a negative relationship between the expected gross margin and business risk reported by the portfolio of crops chosen by the ESBF (i.e. the EPL) when the following assumptions hold: (i) risk averse farmers have the same coefficient of absolute risk aversion (i.e. the same value of the coefficient of absolute risk aversion); (ii) these individuals face different market and material resources barriers that prevent them from choosing crops with high gross margin (i.e. they can only select crops with relatively low levels of gross margin); and (iii) maximising gross margin and minimising business risk are included in the set of farmers’ goals. This idea was formalised as a hypothesis referred to as the hypothesis of optimal path (HOP).

As these assumptions were in general verified in the case of the ESBF considered in the sample, it was anticipated that empirical support of the EPL from this sample would be found. In order to understand this, recall that the analysis conducted in the previous section revealed that these farmers were indeed risk averse and they had the same attitude toward risk (i.e. the HRA and the HSC both hold). This implies that the first assumption described above was verified for the ESBF in the sample. On the other hand, Table 6.4 above shows that most of the farmers in the sample produced traditional crops with relatively low levels of gross margin. This means that assumption (ii) held for these individuals. The exception was found in two farmers (observations 8 and 32) who incorporated crops with high gross margin in their portfolio of crops such as carrots and parsnips. Because assumption (ii) did not hold for these individuals, it was expected that their portfolio of crops would achieve levels of expected gross margin and business risk that did not follow the EPL. Finally, it appears that the farmers in the sample cared about maximising gross margin and minimising risk. This is because the regression conducted in the last section revealed that farmers preferred crops with
higher levels of gross margin and lower levels of business risk. This is not surprising because risk averse individuals will always try to minimise risk when taking decisions and to maximise expected gross margin. For example, suppose that a risk averse farmer has two choices: producing a portfolio of crops composed of crops A and B; or producing a portfolio composed of crops C and D. Assume in addition that this individual does not have any special preference in favour of any of these crops. If both portfolios of crops achieve the same expected gross margin, then it is reasonable to argue that this farmer is indifferent between producing any of them. However, if in addition the portfolio formed of crops A and B achieves lower levels of business risk, then this individual will probably select this portfolio because it offers the same gross margin but with lower business risk. Likewise, if both portfolios achieve the same level of business risk, then the farmer will probably be inclined to choose the one that offers higher levels of expected gross margin.

In order to determine the existence of the EPL, the model described in Expression 5.8 was estimated using Ordinary Least Squares (see Step 2 of the statistical analysis of subsection 5.3.4.3). This model is presented again as follows:

\[
\ln(E_i(\pi)) = \beta_0 + \beta_1 \ln(V_i(\pi))
\]  

(6.7)

where \(E_i(\pi)\) represents the expected gross margin of the portfolio of crops chosen by a farmer \(i\); \(\ln(E_i(\pi))\) is the natural logarithm of \(E_i(\pi)\); \(V_i(\pi)\) is the variance of the gross margin of the portfolio chosen by farm \(i\) which was used as a measure of business risk; \(\ln(V_i(\pi))\) is the natural logarithm of \(V_i(\pi)\); and \(\beta_0\) and \(\beta_1\) are the regression coefficients. Following the MEFT, the following results were expected: \(\beta_0 > 0\) and \(\beta_1 < 0\).
In order to determine whether the estimators of these coefficients were unbiased, the Jarque-Bera and the White Heteroskedasticity tests were conducted (see Section 5.4.6). The first test had a value equal to 0.49 ($p = 0.79$) and the second a value equal to 0.13 ($p = 0.87$). This implies that the null hypotheses establishing that the residual term of the regression comes from a normal distribution and that this term is homoskedastic were not rejected. As a consequence, the estimators of the coefficients of this regression were considered reliable and unbiased. The regression is presented in Table 6.7.

Table 6.7: Regression results. Dependant variable: Expected gross margin (in natural logarithm)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient ($n = 45$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>13.66*** (28.17)</td>
</tr>
<tr>
<td>Business Risk (in natural logarithm)</td>
<td>-0.81*** (-15.70)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.851</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.848</td>
</tr>
<tr>
<td>S.E. Regression</td>
<td>0.114</td>
</tr>
</tbody>
</table>

*P < 0.05, ** P < 0.01, *** P < 0.01, t-ratios in parenthesis.

This table shows that the $R^2$ of this regression presented a value equal to 85.1%. This is an excellent fit considering the fact that cross-section data rarely generates magnitudes of this coefficient larger than 60%. In addition, this table shows that the sign of the intercept was positive and the coefficient of the variable Business Risk was negative. Moreover, these coefficients were both highly significant. This implies that the null hypotheses specified for the HOP (see Step 2 of subsection 5.3.4.3) was rejected. As a result, the HOP and the existence of the $EPL$ were supported by the data. It must be concluded, therefore, that the ESBF in the sample chose crop allocations that allowed them to simultaneously increase gross margin and reduce business risk. That is, these farmers chose allocation of crops that were consistent with the prediction obtained from the MEFT.
It is important to highlight the fact that three outliers were eliminated from this regression (8, 32 and 37). The reason is because these farmers were the only individuals who did not follow the EPL as can be seen in Figure 6.6 in Section 6.4.4. In contrast, a previous analysis revealed that the other farmers were not outliers because dummy variables applied to them were not statistically significant (this more general regression is presented in Appendix R).

This is not surprising for farmers 8 and 32 because, as explained below, these individuals included crops with high levels of gross margin in their portfolio of crops, breaking, in this way, assumption (ii) described at the beginning of the present section. What was unexpected, however, is the case of farmer 37 because this individual chose a portfolio including only crops with low gross margin. This case is formally analysed in Section 6.4.4. This section also analyses the case of the other outliers.

Figure 6.5 shows the EPL estimated for the case of the ESBF in the sample. The outliers were omitted from this figure with the objective of facilitating the visual recognition of this relationship (Figure 6.6 in Section 6.4.4 includes the outliers). Before discussing the implications of this figure, it is important to explain how it was achieved. Each black point represents the combination of expected gross margin and business risk that each farmer in the sample (except the outliers) achieved from his/her portfolio of crops. The line in this figure is a trend line that was added to show how these points follows this trend. This trend line is therefore the EPL. The expected gross margin and business risk were calculated using the information collected from the questionnaire (see Question 4 in Appendix L) and the statistics of the Agro Business Consultants (see the references). In order to calculate the expected gross margin of the portfolio of crops, it was assumed
that farmers had adaptive expectation (see Dougherty, 2007). That is, it was assumed that farmers consider historical data of past gross margin to estimate the gross margin that they will obtain in the future (see part (a) of Section 5.3.4.3). The values of expected gross margin used in Figure 6.5 were obtained using historical data of gross margin from 2003 to 2007 of the crops that these farmers harvested in 2008 (see Question 4 in Appendix L) and they were weighted according to the proportion of land occupied by these crops. For example, suppose that a farmer chose a portfolio of crops formed of crops A and B. Suppose that this farmer occupied 70% of the land by crop A and 30% by crop B. Finally, assume that the average of historic data of past gross margin is £100/ha for crop A, and £200/ha for crop B. In this case the expected gross margin of the portfolio of crops is given by: 0.7*£100/ha + 0.3*£200/ha = £130/ha.

For business risk, on the other hand, the variances of historic values of gross margin of single crops adopted by the farmers in the sample and their covariances were used to obtain a measure of business risk. This measure is the variance of the portfolio of crops which is calculated using the variances of historic gross margin of single crops and their covariances (Footnotes 1 and 2 explain why this is an indicator of business risk). For illustrative purposes, consider again the example of the farmer who formed a portfolio composed of crops A and B. Let \( V_A \) and \( V_B \) be the variances of the historic data of gross margin of crops A and B, respectively, and let \( \text{COV}(A;B) \) be the covariance of the historic gross margin of these crops. The variance of the portfolio is calculated using the following formula (see Appendix E): \( \theta^2 V_A + (1 - \theta)^2 V_B + 2 \theta (1 - \theta) \text{COV}(A;B) \). In this example it was assumed that the farmer occupied 70% of the land by crop A and 30% by crop B. This means that \( \theta = 0.7 \) and \( \theta = 0.3 \). Let assume in addition that \( V_A = £2250/ha^2 \), \( V_B = £2400/ha^2 \) and \( \text{COV}(A;B) = -£2200/ha^2 \). Using this information, the variance of the portfolio is equal to: \( \theta^2 V_A + (1 - \theta)^2 V_B + 2 \theta (1 - \theta) \text{COV}(A;B) = \)
$0.7^2 \times £250/ha^2 + 0.3^2 \times £400/ha^2 - 0.7 \times 0.3 \times £200/ha^2 = £117/ha^2$. For this example, therefore, the portfolio of crops chosen by this farmer achieved an expected gross margin value equal to £130/ha (calculated above) and a variance equal to £117/ha². This combination of expected gross margin and business risk is what is depicted in Figure 6.5 as a black point. That is, each black point represents a combination of expected gross margin and variance of the portfolio of crops chosen by each farmer considered in this figure. Other concrete examples of how the expected gross margin and the variance of the portfolio defined in this way are calculated are presented in Appendices E, I and J.

![Figure 6.5: The efficient portfolio line (EPL) relationship](image)

The main implication of the relationship depicted in this figure is that the assumption of the existence of a representative farmer does not hold. This is an important implication because some academic works have used this assumption in econometric and mathematical optimisation frameworks to predict farmers’ responses to policy reforms.
and changes in market conditions (see, for example, Gomez-Limon et al., 2003; Lien, 2002; Hardaker et al., 1997; Lin et al., 1974; and Officer and Halter, 1968). The results obtained in the present section suggest that these academic works could be biased as farmers, even when having the same attitudes towards risk, chose portfolio of crops achieving different levels of expected gross margin and business risk. This is due to the fact that these individuals faced different market and resource barriers that prevented them from selecting the same allocation of crops.

This source of asymmetry is not normally considered by alternative methods. The MEFT proposed in this thesis, by contrast, considers these asymmetries and the model is therefore able to capture heterogeneous farmers’ cropping decisions, offering, in this way, an alternative, richer and novel analytical approach to studying farmers’ behaviour. It appears that no related academic work has been able to capture heterogeneous crop allocations for farmers having similar attitudes towards risk.

On the other hand, it is interesting to notice that the observations shown in Figure 6.4 were not perfectly aligned along the EPL. What causes farms to be “off-line”? According to the theoretical development presented in Sections 4.3.2 and 4.3.3, these deviations around the EPL are explained by a number of factors associated with the approaches included in the proposed multivariate model (see Figure 6.1). Identifying these factors is the objective of next section.

6.4.3 Testing the HNE, HIC and HSI

According to the theoretical development presented in Chapter Four, deviations around the EPL are explained by a number of factors associated with the approaches that form
part of the proposed multivariate model shown in Figure 6.1. They correspond to differences in farmers’ goals (i.e. variables that belong to the multiple goals approach described in Section 3.4); differences in farmers’ attitudes toward different aspects of farming, perceived behavioural control, and subjective norms (i.e. variables that belong to the theory of planned behaviour described in Section 3.5); differences in market barriers facing the ESBF (see Section 3.6); and differences in farmers’ capacity to develop dynamic capabilities (DC) (i.e. different drivers of DC available for these individuals as explained in Section 4.3.3). In order to capture deviations from the EPL caused by these factors, a number of variables defined in Step 3 of Section 5.3.4.3 were considered in the regression analysis developed in this section. In order to specify hypotheses related to these variables, they were classified as follows. The set of social-psychological drivers and restrictions relating to the groups’ farming goals; farmers’ attitudes toward farming; perceived behavioural control; subjective norms; market barriers; and material resources barriers were classified as non-economic drivers. Self-motivation was classified as a driver of DC associated with individual characteristics. Finally, collaborative alliances and social networks were classified as drivers of DC associated with social interaction. Using these classifications the following hypotheses were established with the objective of identifying the factors that explained deviations around the EPL:

(1) **Hypothesis of non-Economic Drivers (HNE):** This hypothesis establishes that farmers’ cropping decisions are influenced by non-economic drivers.

(2) **Hypothesis of determinants of dynamic capabilities associated with individual characteristics (HIC):** This hypothesis establishes that among the determinants
associated with individual characteristics, only differences in self-motivation and attitudes towards risk generate deviations around the EPL.

(3) **Hypothesis of determinants of dynamic capabilities associated with Social Interaction (HSI):** This hypothesis establishes that when farmers face market and material resources barriers preventing them from producing crops with high levels of gross margin, social interaction (i.e. participation in collaborative alliances and social networks) can only generate deviations around the EPL when it helps farmers either to gain negotiation power or productive efficiency.

The objective of the present section is to test these hypotheses by estimating the Equation 5.10 in Chapter Five. This equation is presented again as follows.

\[
\ln(E(\pi)) = \beta_0 + \beta_1 \ln(V(\pi)) + \sum_i \beta_i G_i + \sum_j \beta_j A_j + \sum_k \beta_k P_k + \sum_l \beta_l \ln(V(\pi)) + \sum_m \beta_m MB_m + \sum_n \beta_n MRB_n + \beta_o SM_o + \beta_p CA_p + \beta_q SN_q
\]

(6.8)

where \(E(\pi)\) represents the expected gross margin of the portfolio of crops chosen by a farmer \(i\); \(\ln(E(\pi))\) is the natural logarithm of \(E(\pi)\); \(V(\pi)\) is the variance of the gross margin of the portfolio of crops chosen by farm \(i\) which was used as a measure of business risk; \(\ln(V(\pi))\) is the natural logarithm of \(V(\pi)\); and the \(\beta\)s are the regression coefficients. The variables \(G_i, A_j, P_k, N_o, MB_m, MRB_n, SM_o, CA_p,\) and \(SN_q\) denote farmers’ goals, farmers’ attitudes toward farming, perceived behavioural control, subjective norms, market barriers, material resources barriers, self-motivation, collaborative alliances, and social networks, respectively. This equation is virtually equal to
Expression 6.7 because both represent the \( EPL \). The only differences is that Equation 6.8 also includes variables that could generate deviations around the \( EPL \) (i.e. \( G_i, A_j, P_k, N_l, MB_m, MRB_n, SM_o, CA_p, \) and \( SN_q \)).

In order to test the HNE, HIC and HSI, Equation 6.8 was estimated using a stepwise linear regression. The results are presented in Table 6.8.

### Table 6.8: Regression results. Dependant variable: Expected gross margin (in natural logarithm)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient ( (n = 44) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>13.36*** (61.05)</td>
</tr>
<tr>
<td>Business Risk (in natural logarithm)</td>
<td>-0.83*** (-40.61)</td>
</tr>
<tr>
<td>Maintaining the family tradition</td>
<td>-0.03*** (-3.84)</td>
</tr>
<tr>
<td>Provide for next generations</td>
<td>-0.04*** (-3.84)</td>
</tr>
<tr>
<td>Have independence and freedom from supervision</td>
<td>0.08*** (8.05)</td>
</tr>
<tr>
<td>I regularly negotiate with suppliers and buyers</td>
<td>0.04*** (2.89)</td>
</tr>
<tr>
<td>Farming is still fun and satisfying</td>
<td>-0.02* (-2.48)</td>
</tr>
<tr>
<td>I'm well informed on the relevant legislation for my farm</td>
<td>-0.07*** (-5.39)</td>
</tr>
<tr>
<td>I can further lower my production costs</td>
<td>0.05*** (6.84)</td>
</tr>
<tr>
<td>The way other farmers think about my farm is important to me</td>
<td>-0.04*** (-5.77)</td>
</tr>
<tr>
<td>Specialisation in order to obtain high production</td>
<td>0.04*** (4.46)</td>
</tr>
<tr>
<td>Collaborative alliances to increase negotiation power</td>
<td>0.02*** (3.30)</td>
</tr>
<tr>
<td>Retailers demand quality that it is difficult to achieve</td>
<td>0.04*** (4.12)</td>
</tr>
<tr>
<td>Retailers demand a volume that I cannot produce</td>
<td>0.05*** (5.25)</td>
</tr>
<tr>
<td>I am not able to innovate to the extent required to enter the market</td>
<td>0.05*** (5.20)</td>
</tr>
<tr>
<td>Dummy variables for farmers located near Wolverhampton</td>
<td>-0.12*** (-7.64)</td>
</tr>
<tr>
<td>Dummy variables for farmers located near Worcester</td>
<td>-0.28*** (-6.71)</td>
</tr>
</tbody>
</table>

\[ R^2 \] 0.988  
Adjusted \[ R^2 \] 0.981  
S.E. Regression 0.040

\( ^*P < 0.05, \ ^{**}P < 0.01, \ ^{***}P < 0.01, \ t\text{-ratios in parenthesis. Note that the econometric programme eliminated one of the observations because a particular farmer omitted some of the questions in the questionnaire.} \)

The regression results presented in Table 6.8 revealed a very high explained variation. That is, the magnitude of the coefficient of determination of this regression was 98.8%. In order to provide possible explanations to this result, remember that the regression
model presented in this table is the same model than the one presented in Table 6.7. The only difference is that the regression in Table 6.8 also considers several variables that were introduced with the objective of explaining deviations around the regression line presented in Figure 6.5 (i.e. around the EPL). These formulations are described as follows:

\[(i) \text{ Equation presented in Table 6.7: } \ln(E(\pi)) = \beta_0 + \beta_1 \ln(V(\pi))\]

\[(ii) \text{ Equation presented in Table 6.8: } \ln(E(\pi)) = \beta_0 + \beta_1 \ln(V(\pi)) + \theta\]

Where \(\theta\) represents other variables (these variables are formally described in Equation 6.8). Because the \(R^2\) in regression \((i)\) was 0.851 (see Table 6.7) and the \(R^2\) in regression \((ii)\) was 0.988 (see Table 6.8), it was inferred that most of the variation was explained by the negative relationship between expected gross margin and business risk itself accounting for about 85\% of the variation (i.e. the relationship given by \(\ln(E(\pi)) = \beta_0 + \beta_1 \ln(V(\pi))\)). In contrast, the contribution of non-economic drivers identified in Table 6.8 (i.e. the set of variables represented by the symbol \(\theta\) in equation \((ii)\) above) accounted for less than 14\% of the total variation explained by this regression. This means that the variables that caused deviations around the EPL explained a small fraction of the total variation of the dependent variable.

The question is why the results captured this strong relationship between expected gross margin and business risk. There are three possible explanations. Firstly, it is possible that the data was biased as a consequence of the survey technique adopted in the research. That is, because the sample was obtained from a snow ball technique, it is possible that these individuals were like minded. As a consequence, these farmers chose portfolio of crops along a predictable pattern that was consistent with their liked minded
behaviour. From this point of view, this predictable pattern was captured by the regression model as a strong relationship between expected gross margin and business risk. Secondly, it is possible that this relationship was spurious and arose as a consequence of the small sample used in the investigation. In order to determine whether the estimators of the regression model were biased, the Jarque-Bera and the White Heteroskedasticity tests were conducted (these tests are defined in Section 5.4.6). The first test had a value equal to 0.52 (p = 0.77) and the second a value equal to 0.99 (p = 0.53). This implies that the residual term of the regression comes from a normal distribution and is homoskedastic. As a consequence, the estimators of the coefficients of this regression were considered reliable and unbiased. This result suggests, therefore, that potential biases would be associated with the farmers’ liked minded factor rather than sample size. Finally, the last explanation for the high magnitude of the $R^2$ obtained in Equation (i) is because it indeed reflects the predictions obtained from the MEFT proposed in this thesis. As shown in Appendix H, the Equation (i) was formally derived from the assumptions of MEFT. This suggests, therefore, that the negative relationship between expected gross margin and business risk identified in Tables 6.7 and 6.8 reflects an optimal behaviour of farmers facing different market and material resource restrictions which is strongly consistent with the EPL relationship predicted by the MEFT. Given these three possible explanations, it is important to highlight the fact that while the results obtained in these tables strongly support the MEFT, they also could reflect biases associated with farmers who were liked minded. As a consequence, the results have to be considered with caution.

Let us now analyse the variables that were significant in explaining deviation around the $EPL$. According to the results obtained in Table 6.8, two classes of determinants explaining deviations around the $EPL$ were significant: non-economic drivers; and
drivers of DC associated with social interaction. As a consequence, the HNE and HSI were both supported by the data. In contrast, the HIC was not supported because the statements “I am not interested in producing other crops with high gross margin” and “I am not familiar with the productive process of crops higher levels of gross margin” used to capture self-motivation were not statistically significant.

These results suggest, therefore, that defender farmers, even when adopting the same defender strategy, had important differences in terms of the portfolio of crops they chose in response to the closure of the ASBF. These differences were explained not only by existing resources and physical barriers that explains the existence of the EPL, but also by a number of factors including social-psychological variables and the capacity to develop DC.

The discussion developed below offers some arguments to explain why these variables were significant. Some of these explanations were based on informal interviews that the author of this thesis had with the respondents after they filled the questionnaire. This strategy helped to identify some key features of the farming activity of the ESBF that were useful in explaining some of the results. However, it is important to stress the fact that because the farmers in the sample were obtained using a snow ball technique, it is possible that these individuals were liked minded. As a consequence, their opinion could eventually reflect the opinion of only a fraction of the ESBF of the West Midlands region. This is why the results obtained in this section have to be considered with caution. Having clarified this source of bias, the results obtained in Table 6.8 are explained as follows.

a) Goals
Maintaining the family tradition: Farmers who assigned a higher value to this goal chose a portfolio of crops with lower expected gross margin per unit of business risk. This result reflects the opinion given by some farmers in the sample. According to these individuals, they preferred to adopt crops with low gross margin in order to maintain family tradition in terms of maintaining the same agricultural practices to produce traditional crops, and to enjoy more free time with their families. This is because traditional crops are less time demanding than crops with high gross margin such as carrots or parsnips.

Provide for next generations: Farmers who assigned a higher value to this goal chose a portfolio of crops with lower expected gross margin per unit of business risk. This result is associated with the goal “maintaining the family tradition” discussed above. That is, farmers who cared about providing for next generations were also interested in transferring the family tradition to them. Therefore, because these farmers also cared about the family tradition, they achieved lower levels of expected gross margin per unit of business risk as family tradition was associated with the production of traditional crops with low levels of gross margin.

Have independence and freedom from supervision: Farmers who assigned a higher value to this goal chose a portfolio of crops with higher expected gross margin per unit of business risk. This result revealed that farmers who had more independence and freedom from supervision were able to form portfolio of traditional crops achieving higher levels of expected gross margin. A possible explanation for this result is that freedom allowed these farmers to avoid delays in taking good decisions. For example, suppose that a farmer who had not had freedom from supervision identified an
alternative market to sell wheat which offered a better price for this crop. Suppose that this farmer wanted to increase the land occupied by wheat in order to sell a large quantity of this crop in this market. If the supervisor of this individual was not interested in selling in the new market, then the farmer would be unable to increase the production of wheat with the objective of taking advantage of this opportunity.

b) **Attitudes**

*I regularly negotiate with suppliers and buyers*: The coefficient of this attitude was positive meaning that farmers who had more opportunities to negotiate with buyers chose portfolios of crops with higher expected gross margin per unit of business risk. A possible explanation for this result is that these farmers had more access to relevant information from their relationships with suppliers and buyers because they had more frequent contact with these individuals. As a result, they were better informed when making cropping decisions. This possibility has been identified by related academic works. See, for example, Virkkala (2007) and Boahene *et al.* (1999).

*Farming is still fun and satisfying*: The negative coefficient of this attitude implies that the ESBF who believed that farming is still fun and satisfying chose a portfolio of crops with lower expected gross margin per unit of business risk. This result suggests the existence of a trade-off between farming satisfaction and levels of gross margin achieved in the farm. A possible explanation for this trade-off is the fact that crops with high gross margin are very time demanding (see the discussion given above for the goal factor *family farm*). As a consequence, farmers who valued enjoying free time were probably more satisfied when producing less time demanding crops and, therefore, with lower gross margin.
c) *Perceived behavioural control*

*I'm well informed on the relevant legislation for my farm:* Farmers who assigned a higher value to this variable chose a portfolio of crops with lower expected gross margin per unit of business risk. A possible explanation is associated with the trade-off between farming satisfaction and levels of gross margin described above. That is, farmers who were more informed on the relevant legislation of their farms were also able to identify some sources of income such as the Single Payment Scheme. As a consequence, using these sources of income could have helped them to reduce this trade off. This is because the loss of income arising from the adoption of crops with low gross margin to enjoy more free time can be compensated with these sources of income.

*I can further lower my production costs:* Farmers who assigned a higher value to this goal chose a portfolio of crops with higher expected gross margin per unit of business risk. That is, these farmers chose a portfolio of crops with a smaller proportion of crops with low gross margin. A possible explanation for this result is that farmers who were more efficient in terms of reducing costs were able to ensure a certain level of gross margin from traditional crops using a smaller area of land. This then provided them with the opportunity to increase the land covered by riskier crops with relatively higher levels of gross margin such as potatoes, among others.

d) *Subjective norms*
The way other farmers think about my farm is important to me: The negative coefficient of this variable implies that the ESBF who cared about the opinion of other farmers chose a portfolio of crops with lower expected gross margin per unit of business risk. In order to provide an explanation to this result, remember that it was determined in Chapter Two that farmers in the West Midlands region have on average specialised in the production of traditional crops. Considering this information, this result could reflect the fact that the ESBF in the sample were less willing to innovate in crops with high gross margin because they preferred to follow the regional average cropping trend adopted by other farmers. That is, they preferred to follow this trend because they were influenced by the opinion of these farmers.

e) **Material Resources Barriers**

*Specialisation in order to obtain high production*: Farmers who assigned a higher value to this strategy chose a portfolio of crops with a higher expected gross margin per unit of business risk. This result is consistent with the opinion given by most of the ESBF in the sample. These farmers said that they preferred to select crops with a low degree of risk and to specialise in them in order to obtain higher production. According to these farmers, this specialisation allowed them to improving their competitive position in the market of traditional crops even when facing material resources barriers such as capital constraints. This is because specialisation has two advantages. Firstly, it requires the same machinery and equipment to be used for related crops included in their portfolios. Second, it requires a reduced number of workers. The specialisation allowed the farmers to increase production and, in this way, reduce the average cost leading to a positive effect on the gross margin of the portfolio. This result is consistent with the findings obtained in the analysis of dynamic capabilities (DC) developed in Section 6.3.
According to this analysis, there were few available determinants of DC for the ESBF. As a consequence, the best choice for these individuals was to specialise in related traditional crops with low gross margin. The reason is because these individuals had core competences in the production of these crops. As a consequence, adopting a defender strategy was the optimal choice for the ESBF given their knowledge of traditional crops, their core competences in the production of these crops, and the barriers preventing them from adopting crops with higher levels of gross margin. In synthesis, specialising in few traditional crops appeared to be the best option of farmers facing material resources restrictions.

f) Determinants of DC associated with social interaction

*Collaborative alliances to increase negotiation power:* Farmers who assigned higher value to this strategy chose a portfolio of crops with higher expected gross margin per unit of business risk. This result is consistent with the prediction obtained from the MEFT. That is, collaborative alliances formed with the objective of gaining countervailing power in the relationship between supplier and retailers generate deviations around the *EPL*. This is because these alliances help farmers either to adopt crops with higher levels of gross margin when removing marker barriers or to obtain better prices for their existing production. This argument was actually confirmed by several farmers in the sample who belonged to farm associations. These associations collect the production of the members into a pool of crops which is then sold in retailer markets. Given the size of the pools, these organisations have more negotiation power than individual farmers. As a consequence, farm associations can obtain either better prices for traditional crops or better market access for crops with higher levels of gross margin.
margin. It is no surprising then that these farmers chose a portfolio of crops achieving higher levels of gross margin.

g) Market barriers

According to the regression models presented in Table 6.8, three market barriers prevented farmers from choosing crops with high gross margin. They are: *Retailers demand quality that it is difficult to achieve; Retailers demand a volume that I cannot produce;* and *I am not able to innovate to the extent required to enter the market*. The positive sign of the coefficients of these variables indicates that farmers who assigned a higher value to these barriers chose a portfolio of crops with higher expected gross margin. In order to provide an explanation of this result, note that farmers who assigned a lower value to these barriers were not actually limited by them. That is, the data obtained from the sample revealed that these individuals chose traditional crops with a low gross margin even when being able to produce crops with higher levels of gross margin. In contrast, farmers who assigned a higher value to these barriers chose traditional crops because they had no other choice.

This suggests, therefore, that the first group of farmers had goals other than maximising gross margin. As a consequence, they chose portfolios of crops achieving lower levels of gross margin than farmers who really faced these barriers because maximising gross margin was not an important objective for them. This argument was confirmed in the dynamic stage of the research (see Chapter Seven). Surprisingly, it was found in that stage that not all farmers reacted by choosing crops with high levels of gross margin in the hypothetical situation in which none of them faced material resource barriers. This
revealed that a significant number of farmers in the sample were not gross margin maximisers.

h) Other variables

A number of social-geographical factors that could explain deviations around the EPL were identified in Phase I of the research (see Section 6.2): farmers’ individual characteristics (e.g. age and level of education); farm characteristics (e.g. size of the farm); and geographical location. It is interesting to note that none of the variables related to farmers’ individual characteristics and farm characteristics were significant. The exception was given by geographic location. The variables WV and WR in Table 6.8 correspond to dummy variables representing the ESBF in the sample that were located near the cities of Wolverhampton and Worcester, respectively. The negative sign of the coefficients of these variables means that farmers located in these areas chose portfolios of crops with a lower expected gross margin. There is a plausible explanation for this result given by some farmers in the sample that were located near these cities. These individuals argued that they had to increase the area covered by traditional crops because they faced irrigation restrictions. This is because traditional crops are more suitable for farms having irrigation limitations. As a consequence, these farmers formed portfolios of crops having a larger proportion of traditional crops. This, in turn, negatively affected the level of gross margin achieved by these portfolios.

Finally, the variables D8, D32 and D37 are dummies that were introduced in order to include the outliers identified in the regression presented in Table 6.7. These individuals are analysed in next section.
6.4.4 The Outliers

The multiple efficient frontiers theory (MEFT) postulates that the EPL arises when the following assumptions hold: (i) risk averse farmers have the same coefficient of absolute risk aversion (i.e. the same value of the coefficient of absolute risk aversion); (ii) these individuals face different market and material resources barriers that prevent them from choosing crops with high levels of gross margin (i.e. they can only select crops with low gross margin); and (iii) maximising gross margin and minimising business risk are included in the set of farmers’ goals.

The results obtained in the regression presented in Appendix R revealed that three farmers did not behave as predicted by the MEFT. The objective of this section was to identify the reasons which offer explanations for the existence of these outliers. For this purpose, an investigation into which of the assumptions described above did not hold for these farmers was undertaken. The results of this analysis are presented below.

The outliers identified in the regression presented in Appendix R corresponded to observations 8, 32 and 37. These outliers were named D8, D32 and D37 and are shown in Figure 6.6.
This figure shows the combination of expected gross margin and business risk (or variance as discussed in Footnotes 1 and 2) of the portfolio of crops chosen by the farmers in the sample. Each black point in this figure reflects one of these combinations. For example, Point $b$ in this figure is a farmer who chose a portfolio of crops that achieved an expected gross margin equal to £570/ha and a variance (or business risk) equal to £29,000/ha$^2$.

Two types of farmers can be identified in this figure. Farmers who are located close to the $EPL$ (e.g. farmers $a$, $b$ and $c$), and farmers who are not located close to this line (i.e.
the outlier farmers D8, D22 and D37). The farmers in the first group have in common that they all chose portfolio of crops that do not include crops with high levels of gross margin such as carrots or parsnips. As predicted by the MEFT (see Section 4.3.1), farmers with limited choice will choose portfolios of crops that allow them to achieve the maximum possible gross margin and the minimum business risk when forming their portfolio with the available crops. In addition, when these individuals face different market and resource barriers, their optimal choice is consistent with the EPL. For example, farmer c in figure 6.6 achieved a higher level of expected gross margin per unit of variance than farmers a and b suggesting that this individual faced less market and resources restrictions than farmers a and b. Likewise, because farmer b achieved a higher level of expected gross margin per unit of variance than farmer a, this suggests that the former faced less restrictions than farmer a. As a consequence, farmer c is located in a more competitive position on the EPL than farmer b, and the latter is located in a more competitive position on this line than farmer a.

The other farmers who are not located close to the EPL were considered outliers because they did not behave as predicted by the MEFT. The reason is that some of them (the outliers D8 and D32 in Figure 6.6) had not limited choice and, as a consequence, they chose portfolios composed of a mix of crops that included crops with very high levels of gross margin and business risk (see Table 2.3). In particular, farmer D8 included carrots and farmer D32 included carrots, parsnips, raspberries and strawberries. The resulting portfolios, therefore, had higher levels of expected gross margin and business risk than the portfolio of crops chosen by the farmers located along the EPL (i.e. farmers with limited choice). This is why farmers D8 and D32 are located northeast from the EPL as shown in Figure 6.6. In other words, farmers who can access markets of crops with high gross margin will not necessarily follow the EPL because
they have the choice to incorporate these crops into their portfolios and this is captured as a deviation from this line. The main question is why these individuals were able to produce and sell these crops. That is, what made these outliers successful farmers in comparison with the rest of the farmers included in the sample? The answer to this question is provided as follows.

Farmer D8 decided to produce carrots because he had the opportunity to form a collaborative alliance with a grower located in another region of the UK. This strategy helped the farmer to get access to a difficult market by sharing both costs and gross margin. According to the results, this collaboration is the result of the attitude of this farmer towards this business strategy. That is, this agent responded that the formation of collaborative alliances is essential to make the farm a successful business enterprise. In contrast, the non-outliers in the sample responded on average that collaboration was an important strategy but not essential.

Farmer D32, on the other hand, sold his vegetable production (carrots, parsnips and onions) and soft fruits (strawberries and raspberries) direct to consumers in his farm shop located next to the farm. The strategy of this farmer was to diversify production in order to reduce risk and to charge a lower price for his products with respect to the price charged by supermarkets. The main advantage that this farmer had when compared to the non-outliers was that he already had an ensured clientele because the farm shop was a well-established concern. Given that this farm business was successful, it is not surprising that this farmer responded that the only important business strategy is diversification to reduce risk.
Farmer D37, on the other hand, was the only outlier located on the left of the *EPL*. This is because this individual allocated a large proportion of the farm land to the largely risk-free activity of renting out land. Because this activity achieves low income, it was not surprising then that the resulting portfolio achieved a low level of gross margin. This suggests that the main objective of this farmer was to reduce business risk rather than to maximise gross margin. Choosing a free of risk activity, therefore, was for this individual the best option to reduce the business risk of the portfolio after the closure of the ASBF. In terms of the assumptions described above, this farmer departed from the *EPL* because the assumption (*iii*) did not hold for this individual.

### 6.5 Conclusions

According to the results obtained in Phase II of the research, the farmers in the sample had on average few opportunities to develop dynamic capabilities. As a consequence, they adopted a defender strategy in terms of the Miles and Snow’s typology because they had core competences in the production of traditional crops with low levels of gross margin. In this context, specialising in the production of these crops offered them the possibility of using their existing knowledge to sustain competitive advantage. Specialisation also allowed them to use their existing machinery to produce new traditional crops because this machinery was suitable for the production of these crops. In contrast, obtaining specific machinery for the production of crops with high gross margin was not an option for these farmers as most of them faced access to capital constraints.

Lack of opportunity to develop dynamic capabilities explains why the ex-sugar beet farmers adopted a defender strategy in response to the closure of the factory located at...
Allscott after the implementation of the Sugar Regime reform. This, however, did not prevent them from adopting optimal strategies within their limitations. According to the Multiple Efficient Frontiers theory developed in this thesis, farmers facing different market and physical barriers such as land quality were still able to improve their business position. They were able to do that by choosing portfolios of crops achieving the highest possible levels of expected gross margin per unit of business risk within their limitations. For example, a farmer who was only able to produce barley and wheat (i.e. two typical traditional crops with low gross margin) could have chosen an optimal portfolio by selecting an appropriate proportion of these crops. In this way, this farmer could have obtained the maximum possible gross margin per unit of business risk of this portfolio composed only of barley and wheat.

The Multiple Efficient Frontiers theory predicts the existence of a negative relationship between expected gross margin and business risk when farmers behave in this way. This relationship reflects the optimal portfolio of crops chosen by defender farmers facing different market and physical restrictions. This relationship was called in this thesis the Efficient Portfolio Line. The objective of Phase III of the research was to determine empirically the existence of this relationship. The results provided strong support for this relationship indicating that the farmers in the sample chose portfolio of crops allocated along the Efficient Portfolio Line. That is, these individuals made optimal choices within the boundaries of their restrictions.

It is important to highlight, however, that the observations obtained from the sample used in this research were not perfectly fitted along the Efficient Portfolio Line. That is, minor deviations were identified around this line for most of the farmers included in the sample. According to the multivariate model proposed in this thesis, these deviations
were caused by a number of factors associated with farmers’ goals; social-psychological variables affecting farmers’ strategic behaviour; capacity to develop dynamic capabilities; the existence of some specific market barriers; and geographical location, among others. The empirical results obtained in Phase III of the research revealed that a number of these factors indeed explained the deviations around the Efficient Portfolio Line. This not only provided empirical support to the multivariate model proposed in this investigation, but also showed that heterogeneous strategic behaviour can be found among defender farmers. This constitutes a clear contribution of the present research because most of the related works do not consider this heterogeneous behaviour. For example, the Miles and Snow’s typology can only distinguish among prospector, defender, analyser and reactor individuals. But it cannot identify heterogeneous strategic behaviour within each of these types of individuals.

The novel analysis developed in this chapter also permitted the identification of outlier farmers who did not behave as most of the individuals who chose portfolio of crops along the Efficient Portfolio Line. According to the results, these farmers were outliers because some of the assumptions needed to guarantee the existence of this line did not hold for these individuals. For example, two individuals were able to produce crops with very high levels of gross margin and this allowed them to obtain portfolio with a high level of gross margin.

The results described above were obtained from a static point of view because the analysis was focussed on year 2008. The aim was to use this single year to investigate how farmers adjusted in response to the closure of the Allscott sugar factory. This permitted the validation of five of the six hypotheses established in the static stage of the research: the hypothesis of risk aversion (HRA); the hypothesis of similar
coefficient of absolute risk aversion (HSCRA); the hypothesis of optimum path (HOP); the hypothesis of non-Economic Drivers (HNE); and the hypothesis of determinants of dynamic capabilities associated with Social Interaction (HSI). The hypothesis of determinants of dynamic capabilities associated with individual characteristics (HIC), in contrast, was not supported by the data.

What is not clear from the results obtained in this chapter is whether the ex-sugar beet farmers would be able to improve their competitive position if the government introduced specific programmes of local development. As discussed above, because these individuals faced important barriers that prevented them from adopting crops with high levels of gross margin, they adopted a defender strategy with the objective of taking advantage of their core competence in the production of traditional crops. How would these farmers behave if some of these barriers were removed by means of policy programmes? Would these farmers adopt a defender strategy in a more favourable condition? How non-economic variables would affect their strategic decisions if they were given the choice to operate with more access to capital and better land quality? This is the analysis developed in the next chapter. The next chapter departs from the static paradigm considered so far with the purpose of investigating how farmers would behave if material resource barriers such as limit access to capital were removed.

Finally, it is important to highlight the fact that the results obtained in this chapter could be biased as a result of limitations in the survey sample and in the survey itself. As explained in Section 5.3.3, two types of bias could potentially have affected the results obtained from the survey: non-response bias; and bias associated with the small sample used in the research. The non-response bias could potentially have been introduced from the snow ball strategy adopted in this research because in this technique farmers suggest
friends as possible candidates for the sample. As a consequence, the sample used in the study could have been formed of like minded farmers. This implies that the results obtained in this chapter could reflect the behaviour of a like minded fraction of ESBF rather than the behaviour of the population. On the other hand, the use of a small sample could also have introduced bias. This is because sampling error is normally larger when samples are small and this affects the results obtained from statistical inference analysis.

Two additional sources of bias were identified in this thesis and are related to the questionnaire used in the research (see Section 5.3.2). Firstly, this questionnaire has a significant number of statements. Consequently, answering these statements could have caused fatigue to the respondents negatively affecting the reliability of the survey. Secondly, some question required the farmers to make judgments and decisions in hypothetical unknown scenarios (i.e. under uncertainty). In order to identify opportunities in these sceneries, the farmers probably needed higher levels of informational processing (for a discussion, see Keh et al., 2002). It is possible that the participants answered these questions with lack of accuracy in order to avoid the associated informational processing. Given these potential sources of biases, it is advised to consider the results obtained in this chapter with caution.
Chapter Seven: FINDINGS AND RESULTS IN THE DYNAMIC STAGE OF THE RESEARCH

7.1 Introduction

The findings obtained in the static stage of the research developed in Chapter Six revealed that the ex-sugar beet farmers of the West Midlands region (ESBF) generally had few opportunities to develop dynamic capabilities when the reform of the Sugar Regime (SRR) was implemented in 2006. As a consequence, these farmers adjusted to the closure of the Allscott Sugar factory (ASBF) by adopting a defender strategy. This consisted of adopting crops with low gross margin with the purpose of maintaining their competitive position in the market of traditional crops. However, the results also showed that this strategy was not adopted homogeneously by the ESBF. In particular, it was found that these individuals were able to form portfolios of traditional crops that allowed them to achieve desirable levels of expected gross margin and business risk (this concept is defined in Footnote 1 in Chapter One) within the scope of their restrictions (i.e. market and material resources barriers such as capital constraints). That is, these individuals adopted the strategy of selecting portfolios of crops achieving optimal levels of expected gross margin per unit of business risk in order to reach some particular objectives, and this strategy was influenced by a number of social-psychological variables.
It is important to stress the fact that the results of the static stage of the research developed in the last chapter were obtained in a context in which most of the ESBF faced both market and material resource restrictions. That is, it was identified that farmers’ cropping and strategic decision making had been limited by these constraints. What would be interesting to investigate from these findings is how the ESBF would behave if they were given the material resources needed to develop dynamic capabilities (e.g. by implementing policy programmes of local development). The question that this poses is, which combination of expected gross margin and business risk would the farmers choose if they were given these resources? Would they choose the same traditional crops to reach these desirable levels of expected gross margin and business risk or would they select new crops for this purpose? Could the existence of market barriers such as power imbalance in the relationship retailers-producers prevent them from adopting crops with high levels of gross margin if they were given the material resources needed to develop dynamic capabilities? Would non-economic drivers be more important than economic drivers in explaining how the ESBF would select their cropping plans if these resources were available? This set of questions is important from a policy development perspective as it will allow us to test which constraints have the biggest effect on reducing farmers’ ability to react more effectively to large scale shocks in their operating environment. An understanding of the relative impact of these constraints is important to a policy development standpoint in terms of helping shape and define better support policies and programmes.

The objective of the present chapter was to investigate these issues by means of an experimental method. In this approach, the ESBF were asked to describe the cropping choices that they would make if they were given all the material resources needed to develop dynamic capabilities (see Question 10 in Appendix L) i.e. if they did not have
capital restrictions, irrigation restrictions, and land quality restrictions. This analysis was said to be dynamic because this compared the crop allocations that the ESBF reported in the experimental method with the real allocations chosen by these individuals after the closure of the ASBF.

This chapter is organised as follows. Section 7.2 shows the results obtained in the experimental method. Section 7.3 discusses the managerial and policy implications of the findings. Finally, Section 7.4 summarises and concludes the chapter.

7.2 Results of the Dynamic Stage of the Research: testing the HAD and the HAE

7.2.1 Strategic Behaviour in Response to the Exogenous Shock

As shown throughout the present chapter, the results of the dynamic stage of the research revealed that the ESBF responded heterogeneously in response to the theoretical removal of material resource restrictions. Some of them behaved as predicted by the HAD and the HAE (i.e. the hypotheses established for the current dynamic stage of the research. See the introduction of Chapter Five). However, others showed a completely different strategic behaviour revealing that non-economic drivers were important in explaining their cropping choices. This heterogeneous behaviour is presented in Figures 7.1 and 7.2. These figures shows the levels of expected gross margin and business risk of the portfolios of crops chosen by the farmers in the sample in response to the removal of material resource restrictions (i.e. after the exogenous shock). The black circles in these figures represent the allocations of crops that the farmers chose after the introduction of the shock. The white triangles, in contrast,
represent the allocation of crops chosen by these individuals before the incidence of the shock\textsuperscript{12}. The main differences between Figures 7.1 and 7.2 is that the latter presents the axes in natural logarithm and these axes were truncated. These modifications were introduced in Figure 7.2 with the objective of facilitating the visual recognition of the \textit{EPL}.

Figure 7.1 Effect of an Exogenous Shock on the Levels of Gross Margin and Business Risk of the Portfolios of Crops.

\textsuperscript{12} The variance of the gross margin of the portfolio of crops was used as a measure of business risk. Footnote 2 in Chapter Two and Section 5.3.4.3 explain why this is an appropriate indicator of business risk.
In general terms, it is possible to distinguish two groups of farmers from Figure 7.2: (i) farmers who departed from the \textit{EPL} in response to this shock; and (ii) farmers who remained on this line\textsuperscript{13} (this line has been identified with a red ellipse in Figures 7.1 and 7.2). In order to identify these individuals, a regression analysis that pooled the data on farmers was developed. In this analysis, the regression considered the allocations of crops chosen by each farmer before and after the introduction of the technological improvement as two different observations. Because there were 48 farmers in the sample, 96 observations were included in the regression. In order to identify outliers

\textsuperscript{13} A formal discussion of how this line is generated is presented in Section 4.3.1 and in particular in Subsection 4.3.1.3. A more elaborated derivation of this line in mathematical terms is presented in Appendix D.
from the data pool, two sets of different dummy variables were considered. Set A corresponds to the set of dummies that were employed to identify outliers with respect to the EPL after the introduction of the exogenous shock., i.e. these dummy variables were introduced with the objective of identifying farmers who became outliers after the removal of material resource material constraints. For example, A6 means that the observation number six of the sample is a farmer who became an outlier after the incidence of the shock. Set B, on the other hand, corresponds to the set of dummies that were employed to identify outliers before the introduction of the exogenous shock. For example, B37 means that the 37th observation of the sample is a farmer who was an outlier before the incidence of the technological shock. The estimated model is formally presented in Table 7.1.

Table 7.1 Regression Results. Dependant Variable: Logarithm of the Expected Gross Margin of the Portfolio of Crops, \( \ln(E(\pi)) \)

<table>
<thead>
<tr>
<th>Variables</th>
<th>( (n = 96) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>13.40***((39.32))</td>
</tr>
<tr>
<td>Logarithm of Business Risk, ( \ln(V(\pi)) )</td>
<td>(-0.78***(-21.48))</td>
</tr>
<tr>
<td>Dummy for farmer 1 who became an outlier after the shock (A1)</td>
<td>3.28***((22.53))</td>
</tr>
<tr>
<td>Dummy for farmer 3 who became an outlier after the shock (A3)</td>
<td>4.18***((24.75))</td>
</tr>
<tr>
<td>Dummy for farmer 6 who became an outlier after the shock (A6)</td>
<td>4.41***((24.69))</td>
</tr>
<tr>
<td>Dummy for farmer 8 who became an outlier after the shock (A8)</td>
<td>2.29***((17.81))</td>
</tr>
<tr>
<td>Dummy for farmer 24 who became an outlier after the shock (A24)</td>
<td>4.71***((26.34))</td>
</tr>
<tr>
<td>Dummy for farmer 25 who became an outlier after the shock (A25)</td>
<td>3.10***((22.34))</td>
</tr>
<tr>
<td>Dummy for farmer 27 who became an outlier after the shock (A27)</td>
<td>3.25***((21.39))</td>
</tr>
<tr>
<td>Dummy for farmer 37 who became an outlier after the shock (A37)</td>
<td>4.16***((25.09))</td>
</tr>
<tr>
<td>Dummy for farmer 42 who became an outlier after the shock (A42)</td>
<td>3.99***((25.06))</td>
</tr>
<tr>
<td>Dummy for farmer 45 who became an outlier after the shock (A45)</td>
<td>4.44***((25.58))</td>
</tr>
<tr>
<td>Dummy for farmer 46 who became an outlier after the shock (A46)</td>
<td>5.70***((29.12))</td>
</tr>
<tr>
<td>Dummy for farmer 8 who was an outlier before the shock (B8)</td>
<td>2.07***((16.31))</td>
</tr>
<tr>
<td>Dummy for farmer 32 who was an outlier before the shock (B32)</td>
<td>1.43***((12.12))</td>
</tr>
<tr>
<td>Dummy for farmer 37 who was an outlier before the shock (B37)</td>
<td>-0.40**((-3.43))</td>
</tr>
</tbody>
</table>

\( R^2 \) | 0.97 |
| S.E. Regression | 0.11 |

*\( P < 0.05 \), ** \( P < 0.01 \), *** \( P < 0.001 \) t-ratios in parenthesis.
According to this regression, the observations 1, 3, 6, 8, 24, 25, 27, 37, 42, 45 and 46 are farmers who became outliers after the incidence of the exogenous shock. That is, they are farmers who chose portfolios of crops achieving higher levels of expected gross margin and business risk in response to the removal of material resource restrictions. In other words, they are PRE farmers under the Income-Risk Matrix typology (see Section 4.4.2) and this finding supports the HAD. As a consequence, this hypothesis was accepted only for these individuals. Observations 8, 32 and 37, on the other hand, are the farmers who were outliers before the incidence of the shock. These farmers were also identified in the analysis given in Phase III (see Section 6.4). Note that Farmers 8 and 37 were outliers before and after the technological improvement. In contrast, Farmer 32 is the only one that used to be an outlier before but not after this improvement.

To prove that the farmers who became outliers after the introduction of the exogenous shock behaved as predicted by the HAD, let us consider the following definitions (these definitions are described in more detail in Appendices S and T). Let \( \text{GM}_B \) and \( \text{VGM}_B \) be the average and variance of the expected gross margin of the portfolios of crops chosen by these farmers \textit{before} the incidence of the exogenous shock, respectively. Let \( \text{GM}_A \) and \( \text{VGM}_A \) be the average and variance of the expected gross margin of the portfolios of crops chosen by these farmers \textit{after} the implementation of the shock, respectively. Let \( \text{BR}_B \) and \( \text{VBR}_B \) be the average and variance of the business risk of the portfolios of crops chosen by these individuals \textit{before} the incidence of the exogenous shock. Finally, let \( \text{BR}_A \) and \( \text{VBR}_A \) be the average and variance of the business risk of the portfolios of crops chosen by these farmers \textit{after} the implementation of the shock. The (MEFT) predicts that farmers who depart from the \textit{EPL} choose portfolio of crops achieving higher levels of gross margin (i.e. \( \text{GM}_B < \text{GM}_A \)) and business risk (i.e. \( \text{BR}_B < \text{BR}_A \)) in
response to the exogenous shock. This is the central idea of the HAD. Therefore, in
order to determine whether the HAD holds for the farmers in the sample, the following
null and alternative hypotheses were specified:

\[ H_0: \text{GM}_B = \text{GM}_A; \text{ or } \text{BR}_B = \text{BR}_A \]

\[ H_1: \text{GM}_B < \text{GM}_A; \text{ and } \text{BR}_B < \text{BR}_A \]

Two Student \( t \) tests were conducted to determine whether the \( \text{GM}_B = \text{GM}_A \) and \( \text{BR}_B = \text{BR}_A \). For this purpose, the data presented in Tables 7.2 and 7.3 were employed.

Table 7.2 Average and variance of gross margin of the portfolios of crops chosen by the
farmers who departed from the \( EPL \).

<table>
<thead>
<tr>
<th>Period</th>
<th>Average Gross Margin (( £/ha ))</th>
<th>Variance Gross Margin across Farmers (square ( £/ha ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the Shock</td>
<td>( \text{GM}_B = 515 )</td>
<td>( \text{VGM}_B = 61,251 )</td>
</tr>
<tr>
<td>After the Shock</td>
<td>( \text{GM}_A = 2,286 )</td>
<td>( \text{VGM}_A = 763,305 )</td>
</tr>
</tbody>
</table>

In order gain a better understanding of the meaning of Table 7.2, an explanation of how
the information presented in this table was calculated is provided in Appendix S.

According to this table, the farmers in the sample who departed from the \( EPL \) chose a
portfolio of crops that achieved on average an expected level of gross margin equal to
\( £515/ha \) before the removal of material resource restrictions. The variance of the gross
margin achieved by these portfolios was \( £^261,251/ha^2 \). However, after the removal of
the material resource barriers (i.e. after the shock), these farmer chose portfolios of
crops that achieved on average a higher level of expected gross margin equal to \( £2,286/
The variance of the gross margin achieved by these portfolios also increased from £261,251/ha\(^2\) to £763,305/ha\(^2\). This finding supports the HAD in the sense that these farmers adjusted to the removal of material resources barriers by selecting portfolios of crops with higher levels of expected gross margin.

The other information that is needed to test the HAD described above is presented in Table 7.3:

Table 7.3 Average and variance of business risk of the portfolios of crops chosen by the farmers who departed from the EPL.

<table>
<thead>
<tr>
<th>Period</th>
<th>Average Business Risk (square £/ha)</th>
<th>Variance Business Risk (square Business Risk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the Shock</td>
<td>BR(_B) = 11,474</td>
<td>VBR(_B) = 16,217,419</td>
</tr>
<tr>
<td>After the Shock</td>
<td>BR(_A) = 350,115</td>
<td>VBR(_A) = 56,177,244,737</td>
</tr>
</tbody>
</table>

This information was obtained using a similar approach that the one described for Table 7.2. However, the variable of interest in this case is business risk rather than gross margin. The calculations developed to obtain this information are presented in Appendix T.

According to this table, the average of business risk increased from £211,474/ha\(^2\) to £350,115/ha\(^2\) after the removal of material resource restrictions. Likewise, the variance of business risk increased from £416,217,419/ha\(^4\) to £456,177,244,737/ha\(^4\) after the incidence of this shock. This finding also supports the HAD in the sense that these farmers adjusted to the removal of material resources barriers by selecting portfolios of crops with higher levels of business risk.
Let us now consider the Student $t$ test conducted with the information presented in Tables 7.2 and 7.3. The Student $t$ value obtained from Table 7.2 to determine whether $\text{GM}_B = \text{GM}_A$ was 5.85. The corresponding one-side $t$ table value for 16 degrees of freedom and 5% of significance level is 1.75. Because the $t$ table value was smaller than the $t$ calculated from the data, the equality $\text{GM}_B = \text{GM}_A$ was rejected at the 5% of significance level. On the other hand, the Student $t$ value obtained from Table 7.3 to determine whether $\text{BR}_B = \text{BR}_A$ was 4.29. Since the $t$ table was smaller than this value, the equality $\text{BR}_B = \text{BR}_A$ was rejected. Because the equalities $\text{BR}_B = \text{BR}_A$ and $\text{VBR}_B = \text{VBR}_A$ were both rejected at the 5% of significance level, it was concluded that the null hypothesis presented above was also rejected. As a result, the HAD was supported by the data.

This implies that the MEFT provided a good description of the behavioural responses of the farmers who departed from the $EPL$ in response to the removal of material resource restrictions in that it allows for the fact that they were farmers who considered simultaneously the economic objectives “gross margin maximisation” and “business risk minimisation”. In the light of these dual economic objectives, these individuals introduced new crops with high levels of gross margin in order to increase the expected gross margin of their portfolios of crops after the incidence of the exogenous shock. The negative effect of this choice was that the introduction of these crops increased the levels of business risk of the portfolios. However, these higher levels of business risk were compensated by the higher levels of expected gross margin obtained from these new crops. The net effect was, therefore, that these individuals were able to increase their expected utility as shown in Figure 4.14 in Chapter Four. The crops adopted by these outlier farmers in response to the exogenous shock are presented in Table 7.4.
Table 7.4 Crops with high gross margin adopted by the outliers after the incidence of the shock

<table>
<thead>
<tr>
<th>Crops adopted after the introduction of the shock</th>
<th>Observation in the sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrots, parsnips, strawberries and raspberries</td>
<td>1, 3 and 25</td>
</tr>
<tr>
<td>Carrots, parsnips and raspberries</td>
<td>46</td>
</tr>
<tr>
<td>Carrots, strawberries and raspberries</td>
<td>37 and 45</td>
</tr>
<tr>
<td>Carrots and parsnips</td>
<td>8, 24 and 42</td>
</tr>
<tr>
<td>Carrots</td>
<td>27</td>
</tr>
<tr>
<td>Strawberries</td>
<td>6</td>
</tr>
</tbody>
</table>

It can be inferred from this table that what prevented the outlier farmers from adopting crops with high levels of gross margin (i.e. carrots, parsnips, raspberries and strawberries) was the existence of material resource restrictions but not market barriers. In fact, if the cropping choices of these individuals were also limited by market barriers, then they would have not adjusted to the exogenous shock by introducing these crops.

Regarding the group of farmers who remained on the EPL (i.e. the non-outlier farmers), on the other hand, it was found that a significant number of these individuals did not behave as predicted by the MEFT; that is to say, the HAE did not hold for these farmers. This is shown in Figure 7.3 (the outliers were omitted in this figure with the purpose of facilitating the visual recognition of the non-outlier farmers):
Figure 7.3 Farmers who remained on the EPL after the incidence of the shock

Contrary to what was expected from the MEFT, not all the farmers moved upwards along the EPL to reach a single point on this line. That is, not all the farmers chose the rational option of selecting a portfolio of crops achieving the highest expected gross margin and lowest business risk in response to the exogenous shock. In order to understand why this implies that the HAE does not hold, note that this hypothesis can only be verified when two conditions hold simultaneously: (i) the average of the gross margin of the portfolio of crops increases after the shock (i.e. $GM_B < GM_A$); and (ii) the business risk associated with the portfolio of crops decreases after the shock (i.e. $BR_B > BR_A$). This is because moving upwards along the EPL requires these conditions to be verified. This provides the opportunity to test the HAE using the following null and alternative hypotheses:

$$H_0: GM_B = GM_A; \text{ or } BR_B = BR_A$$
H₁: \( \text{GM}_B < \text{GM}_A \); and \( \text{BR}_B > \text{BR}_A \)

If the null hypothesis is not rejected, then the HAE cannot be supported because \( H_1 \) is a necessary condition for this hypothesis to hold. Two Student \( t \) tests were conducted to determine whether the \( \text{GM}_B = \text{GM}_A \) and \( \text{BR}_B = \text{BR}_A \). For this purpose, the data presented in Tables 7.5 and 7.6 were employed.

Table 7.5 Average and variance of gross margin of the portfolios of crops chosen by the non-outlier farmers after the incidence of the technological shock.

<table>
<thead>
<tr>
<th>Period</th>
<th>Average Gross Margin (\£/ha)</th>
<th>Variance Gross Margin across Farmers (square \£/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the Shock</td>
<td>\text{GM}_B = 428</td>
<td>\text{VGM}_B = 13,840</td>
</tr>
<tr>
<td>After the Shock</td>
<td>\text{GM}_A = 475</td>
<td>\text{VGM}_A = 21,654</td>
</tr>
</tbody>
</table>

Table 7.6 Average and variance of business risk of the portfolios of crops chosen by the non-outlier farmers after the incidence of the technological shock.

<table>
<thead>
<tr>
<th>Period</th>
<th>Average Business Risk (square \£/ha)</th>
<th>Variance Business Risk (square Business Risk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the Shock</td>
<td>\text{BR}_B = 12,751</td>
<td>\text{VBR}_B = 11,827,581</td>
</tr>
<tr>
<td>After the Shock</td>
<td>\text{BR}_A = 11,512</td>
<td>\text{VBR}_A = 14,485,982</td>
</tr>
</tbody>
</table>

The methods used to obtain the information presented in Tables 7.5 and 7.6 are the same methods used to obtain the information presented in Tables 7.2 and 7.3, respectively. These methods are formally explained after Tables 7.2 and 7.3.
The Student $t$ value obtained from Table 7.5 was used to determine whether $GM_B = GM_A$ was 1.48. The corresponding one-side $t$ table value for 70 degrees of freedom and 5% of significance level is 1.67. Because the $t$ table value was larger than the $t$ calculated from the data, the equality $GM_B = GM_A$ was not rejected at the 5% level of significance. On the other hand, the Student $t$ value obtained from Table 7.6 to determine whether $BR_B = BR_A$ was -1.45. Since the $t$ table is larger than this value (in absolute value), the equality $BR_B = BR_A$ was not rejected. Now, since the equalities $GM_B = GM_A$ and $BR_B = BR_A$ were not rejected at the 5% level of significance, it was concluded that the null hypothesis presented above was not rejected either. This implies, therefore, that the HAE did not hold.

This finding suggests, therefore, that there were other non-economic factors that affected the strategic behaviour of these farmers in the dynamic business environments caused by the introduction of the exogenous shock. The study of these non-economic drivers is the objective of the next sections.

### 7.2.2 Farmers’ Classification According to their Behavioural Response

The Income-Risk Matrix criterion proposed in Section 4.4.2 was adopted to classify the ESBF according to their strategic behaviour in response to the simulated removal of material resource restrictions. The types of farmers identified in this study in terms of this criterion are described as follows.
a) Class 1: Neutral Farmers (NF)

This class is characterised by farmers who, in response to the exogenous shock, chose portfolios of crops with similar levels of gross margin and business risk to those they chose before the shock. While no farmer in the sample obtained exactly the same levels of gross margin and business risk, it was found that some non-outlier farmers (i.e. farmers who remained on the EPL after the shock) experienced small deviations of gross margin and business risk when adjusting to the exogenous shock. Because these deviations were small, they were considered to be random. This is why these farmers were classified as NF.

It is important to highlight the fact that the limit between small and large deviations of gross margin considered in this section was arbitrary. This is because no related research has been developed to study how farmers select their cropping plans in response to the removal of material resource restrictions. As a result, it was not possible to find a reliable indicator of the limit between small and large deviations of gross margin from the literature review. The arbitrary limit considered in this section was fixed as a 10% of the maximum deviation of gross margin experienced by a non-outlier farmer. Formally, let \( \Omega \) be the set of non-outlier farmers (i.e. the farmers who remained on the EPL after the incidence of the exogenous shock); let \( dGM_i = GM_{Ai} - GM_{Bi} \) be the difference between the gross margin of the portfolio of crops chosen by farmer \( i \in \Omega \) after (i.e. \( GM_{Ai} \)) and before (i.e. \( GM_{Bi} \)) the incidence of the exogenous shock; and let \( |dGM_{max}| \) be the maximum deviation \( dGM_i \) in absolute value for all \( i \in \Omega \). Using these definitions, the arbitrary limit between small and large deviations of gross margin was defined as:
Because in the sample the maximum difference $d_{GM_{\text{max}}}$ was 415.6 £/ha, any difference $|d_{GM_i}|$ equal to or smaller than 41.6 £/ha in absolute value (i.e. 10% of $|d_{GM_{\text{max}}}|$) was considered small (i.e. caused by a random error). In other words, a farmer who obtained a $|d_{GM_i}|$ equal or smaller to 41.6£/ha was considered a neutral (NR) farmer. The changes of gross margin and business risk of the portfolios of crops recorded by these individuals are shown in Table 7.7, where $dBR_i = V(\pi_{Ai}) - V(\pi_{Bi})$ is the difference between the variance of the gross margin of the portfolio of crops chosen by farmer $i$ after and before the incidence of the shock, where $V(\pi_{Ai})$ and $V(\pi_{Bi})$ correspond to these variances, respectively\(^{14}\).

\(\text{LIMIT} = 0.1 \times |d_{GM_{\text{max}}}|\)  \hspace{1cm} (7.17)

<table>
<thead>
<tr>
<th>Observation ($i$)</th>
<th>$d_{GM_i}$ (£/ha)</th>
<th>$dBR_i$ (square of £/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>-5.14</td>
<td>-505.20</td>
</tr>
<tr>
<td>10</td>
<td>-4.43</td>
<td>404.94</td>
</tr>
<tr>
<td>11</td>
<td>-3.46</td>
<td>-370.10</td>
</tr>
<tr>
<td>12</td>
<td>14.78</td>
<td>385.62</td>
</tr>
<tr>
<td>14</td>
<td>1.60</td>
<td>2.64</td>
</tr>
<tr>
<td>15</td>
<td>-14.37</td>
<td>-832.31</td>
</tr>
<tr>
<td>17</td>
<td>-7.52</td>
<td>2,046.52</td>
</tr>
<tr>
<td>18</td>
<td>10.83</td>
<td>-1,257.71</td>
</tr>
<tr>
<td>19</td>
<td>19.60</td>
<td>1,354.76</td>
</tr>
<tr>
<td>22</td>
<td>-36.42</td>
<td>-2,723.57</td>
</tr>
<tr>
<td>23</td>
<td>1.60</td>
<td>288.09</td>
</tr>
<tr>
<td>26</td>
<td>-7.66</td>
<td>1,555.83</td>
</tr>
<tr>
<td>38</td>
<td>-27.43</td>
<td>-2,100.91</td>
</tr>
<tr>
<td>39</td>
<td>17.52</td>
<td>-742.35</td>
</tr>
<tr>
<td>44</td>
<td>-10.37</td>
<td>-1,080.12</td>
</tr>
<tr>
<td>48</td>
<td>11.39</td>
<td>770.36</td>
</tr>
</tbody>
</table>

\(^{14}\) As explained in Footnotes 1 and 2, these variances are proxies of business risk.
In order to gain a better understanding of the definitions of $d_{GM}$ and $d_{BR}$, and how the numbers presented in Table 7.7 were obtained, a formal description of the calculations developed to obtain these numbers is presented in Appendix U.

Let us now analyse the case of the NF farmers considered in Table 7.7. The data presented in this table is shown in Figure 7.4

Figure 7.4 Changes of expected gross margin and business risk in response to the removal of material resource barriers: the case of the NF.

The horizontal axis of this figure shows the change of gross margin that was verified after the removal of the material resource barriers (i.e. $d_{GM}$, defined above). The vertical axis, on the other hand, shows the change of business risk after the incidence of this shock (i.e. $d_{BR}$, defined above). This figure presents four quadrants that have been named I, II, III and IV. Each of these quadrants shows a particular relationship between
the change of gross margin and the change of business risk: (i) in Quadrant I it holds that dGM\textsubscript{i} > 0 and dBR\textsubscript{i} > 0; (ii) in Quadrant II it holds that dGM\textsubscript{i} < 0 and dBR\textsubscript{i} > 0; (iii) in Quadrant III it holds that dGM\textsubscript{i} < 0 and dBR\textsubscript{i} < 0; and (iv) in Quadrant IV it holds that dGM\textsubscript{i} > 0 and dBR\textsubscript{i} < 0.

According to the Income-Risk Matrix criterion proposed in Section 4.4.2, the NF farmers should be located in the origin of Figure 7.4. This is because the axes of this figure show changes of gross margin and business risk. But because the NF farmers are classified as individuals who maintain the same levels of expected gross margin and business risk, it should hold for these farmers that dGM\textsubscript{i} = 0 and dBR\textsubscript{i} = 0 which corresponds to the origin of this figure. However, it is difficult to support the idea that farmers can achieve exactly the same levels of these variables because they can be affected by random factors that are out of farmers’ control (e.g. climatic shocks affecting the proportion of land covered by the crops that compose their portfolios). This is why it is expected to find in Figure 7.4 deviations from the origins in any directions reflecting the fact that these random effects could positively or negatively affect either gross margin or business risk. This is actually what is shown in this figure. That is, it is not possible to identify a pattern of the change in gross margin and change of business risk of the portfolios of crops chosen by the NF farmers (the red points in the figure). On the contrary, the red points in Figure 7.4 are located near the origin of the graph and all of them are distributed in the four the quadrants without following a clear pattern. This suggests therefore that these deviations from the origin were caused by random factors. In this figure, the highest deviation from the origin was verified by observation 22 in Table 7.7 and is presented in Quadrant III. The change of gross margin of the portfolio chosen by this individual was dGM\textsubscript{22} = −£36.42/ha and the change of business risk was dBR\textsubscript{22} = −£2,723.57/ha\textsuperscript{2}. This implies that this individual
adjusted to the removal of material resource restrictions by choosing a new portfolio of crops that achieved lower levels of expected gross margin and business risk. In contrast, the smallest deviation was verified by observation 14 and is presented in Quadrant I. The change of gross margin of the portfolio of crops chosen by this individual was $dGM_{14} = £1.6/\text{ha}$ and the change of business risk was $dBR_{14} = £2.64/\text{ha}^2$ implying that this individual adjusted by choosing a portfolio of crops achieving slightly higher levels of expected gross margin and business risk.

While these farmers adjusted by choosing portfolios of crops achieving relatively similar levels of gross margin and business risk as before the shock, the way in which they formed these portfolios varied. In particular, it was found that 69% of the 16 NF chose the same crops as before in response to the exogenous shock. What changed was the proportion in which these crops were placed in their portfolios. That is, they adopted the same portfolios but a different mix of crops. In other words, these farmers were able to maintain their position on the EPL by using the same crops but in different proportions. In terms of the Miles and Snow’s typology, these individuals were classified as defenders because they tended to protect their market share and their current position in the market of traditional crops without introducing innovations. The rest of the farmers, on the other hand, were able to maintain their relative position on the EPL either by adding one or two new traditional crops with low gross margin into their portfolio in response to the exogenous shock (e.g. oilseed rape or barley) or by replacing one or two crops with new crops with low gross margin. In terms of the Miles and Snow’s typology, these farmers were classified as analysers because they tended to maintain their current position by developing some innovation in terms of the introduction of crops with low levels of gross margin.
b) Class 2: Progressive Risk Saver (PRS)

This class of farmers is characterised by individuals who chose portfolios of crops achieving higher levels of gross margin \( (i.e. \ dGM > 0) \) and lower levels of business risk \( (i.e. \ dBR < 0) \). The changes in gross margin and business risk of the portfolios of crops chosen by these individuals are shown in Table 7.8:

Table 7.8 Changes of gross margin and business risk of the portfolios of crops chosen by the PRS.

<table>
<thead>
<tr>
<th>Observation ( (i) )</th>
<th>( dGM_i ) ( (£/ha) )</th>
<th>( dBR_i ) ( (\text{square of £/ha}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>331.96</td>
<td>-6,514.75</td>
</tr>
<tr>
<td>16</td>
<td>43.42</td>
<td>-1,031.50</td>
</tr>
<tr>
<td>20</td>
<td>204.14</td>
<td>-4,655.33</td>
</tr>
<tr>
<td>21</td>
<td>135.61</td>
<td>-5,888.24</td>
</tr>
<tr>
<td>28</td>
<td>193.71</td>
<td>-6,928.83</td>
</tr>
<tr>
<td>29</td>
<td>182.83</td>
<td>-1,503.10</td>
</tr>
<tr>
<td>30</td>
<td>214.50</td>
<td>-3,629.66</td>
</tr>
<tr>
<td>31</td>
<td>289.66</td>
<td>-6,399.89</td>
</tr>
<tr>
<td>33</td>
<td>47.33</td>
<td>-518.94</td>
</tr>
<tr>
<td>34</td>
<td>159.82</td>
<td>-1,587.40</td>
</tr>
<tr>
<td>35</td>
<td>141.45</td>
<td>-5,060.93</td>
</tr>
<tr>
<td>36</td>
<td>81.27</td>
<td>-2,133.79</td>
</tr>
<tr>
<td>40</td>
<td>178.23</td>
<td>-5,836.22</td>
</tr>
<tr>
<td>41</td>
<td>46.47</td>
<td>-2,924.90</td>
</tr>
<tr>
<td>43</td>
<td>415.63</td>
<td>-9,823.47</td>
</tr>
<tr>
<td>47</td>
<td>235.96</td>
<td>-7,786.09</td>
</tr>
</tbody>
</table>

The information presented in this table is plotted in Figure 7.5:
According to this figure, the PRS farmers are presented in Quadrant IV. This quadrant shows a clear pattern consisting of a negative relationship between the change of gross margin (dGM\(_i\)) and the change of business risk (dBR\(_i\)). That is, individuals who chose portfolios of crops that achieved higher levels of expected gross in response to the shock also achieved lower levels of business risk. For example, the observation 36 in Table 7.8 was able to increase expected gross margin by dGM\(_{36}\) = £81.27/ha and to reduce business risk by dBR\(_{36}\) = −£2,133.79/ha\(^2\) when forming the new portfolio in response to the removal of material resource barriers. In contrast, observation 43 was able to achieve a much higher increment of expected gross margin equal to dGM\(_{43}\) = £415.63/ha and a much lower decrease in business risk equal to dBR\(_{43}\) = −£9,823.47/ha\(^2\) in response to the shock. The pattern presented in Quadrant IV is actually what it is expected to be found when farmers adjust by moving upwards along...
the EPL: the higher the expected gross margin achieved by a farmer, the lower level of business risk. This, in turn, is what characterises the PRS farmers.

Four different types of PRS were identified. The first one corresponds to individuals who maintained the same crops in their portfolio after the shock, but changed the proportion of land covered with them in order to reach higher levels of gross margin and lower levels of business risk. They corresponded to 19% of 16 farmers presented in Table 7.8. Regarding the Miles and Snow’s typology, these farmers were classified as defenders because they maintained the same crops without adding any type of innovation. The second type of farmers, accounting for 6% of the 16 individuals presented in Table 7.8, corresponds to individuals who eliminated one or more crops from their original portfolios in response to the exogenous shock. That is, these farmers specialised in existing alternatives that provided them with a higher gross margin and a lower level of business risk. These farmers were also classified as defenders because they eliminated crops with low gross margin in order to maintain their current market position without adding significant innovation activities. Finally, the remaining two types of farmers were classified as prospectors because all of them introduced potatoes as a new crop which has a higher level of gross margin than traditional crops. One of these types of farmers (50% of the 16 farmers presented in Table 7.8), in particular, was formed of individuals who replaced one or two traditional crops (e.g. barley, oilseed rape, peas or oats) with potatoes. The other type (25% of the 16 farmers presented in Table 7.8) comprised farmers who introduced potatoes as a new crop into their existing portfolios of crops.
c) **Class 3: Regressive Risk Enlarger (RRE)**

This class of farmer is characterised by individuals who chose a portfolio of crops which achieved lower levels of gross margin and higher levels of business risk in response to the exogenous shock. Only non-outlier farmers fell into this category. The changes in gross margin and business risk of the portfolios of crops chosen by these individuals are shown in Table 7.9:

Table 7.9 Changes of gross margin and business risk of the portfolios of crops chosen by the RRE.

<table>
<thead>
<tr>
<th>Observation (i)</th>
<th>dGM$_i$ (£/ha)</th>
<th>dBR$_i$ (square of £/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>-311.38</td>
<td>8,551.70</td>
</tr>
<tr>
<td>5</td>
<td>-141.10</td>
<td>5,079.98</td>
</tr>
<tr>
<td>7</td>
<td>-380.30</td>
<td>7,948.41</td>
</tr>
<tr>
<td>9</td>
<td>-354.99</td>
<td>8,850.01</td>
</tr>
</tbody>
</table>

The numbers presented in this table are plotted in Figure 7.6:
The RRE are all presented in Quadrant II in Figure 7.6 meaning that all these individuals chose portfolios of crops achieving higher levels of business risk (dBR, > 0) and lower levels of expected gross margin (i.e. dGM, < 0). It is also possible to identify a pattern in this quadrant consisting of a negative relationship between the change of gross margin and the change in business risk. For example, the level of expected gross margin of the new portfolio of crops chosen by Observation 5 decreased by dGM, = \-\£141.1/ha and the level of business risk of this portfolio increased by dBR, = \£25,079.98/ha². In contrast, the level of expected gross margin of the new portfolio of crops chosen by Observation 9 decreased by dGM, = \-\£354.99/ha and the level of business risk of this portfolio increased by dBR, = \£28,850.01/ha². This pattern suggests, therefore, that the lower the level of gross margin achieved by a RRE farmer when forming the new portfolio of crops in response to the shock, the higher the level of business risk. This relationship is what it is expected to be found when farmers move...
downwards along the EPL. It is important to clarify, however, that this pattern is not as clear as the pattern identified for the case of the PRS farmers shown in Figure 7.5. The reason is because only few individuals were found to behave as RRE farmers making it more difficult to identify the pattern clearly. This could reflect the small sample used in this research. Unfortunately this is the most important limitation of the current research and this is an example of why the results obtained in this investigation have to be considered with caution.

The strategy followed by the RRE farmers is counterintuitive because the economic argument supporting the MEFT postulates that farmers will always try to maximise income (gross margin) and to minimise business risk (variance of gross margin). In this sense, these farmers acted as irrational agents as they eliminated a crop with a higher level of gross margin than traditional crops in their portfolios in response to the technological shock. This crop was potatoes which has a higher gross margin than traditional crops such as wheat, barley, oilseed rape and oats, among others. This is formally shown in Table 7.10:

Table 7.10 Importance of potatoes in relation with traditional crops.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Gross Margin (£/ha)</th>
<th>Variance Gross Margin (square £/ha)</th>
<th>Covariance with Potatoes (square £/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>1,925</td>
<td>43,472</td>
<td>---------</td>
</tr>
<tr>
<td>Wheat</td>
<td>472</td>
<td>19,941</td>
<td>-13,234</td>
</tr>
<tr>
<td>Oats</td>
<td>408</td>
<td>15,728</td>
<td>-11,374</td>
</tr>
<tr>
<td>Barley</td>
<td>379</td>
<td>14,025</td>
<td>-11,558</td>
</tr>
<tr>
<td>Oilseed rape</td>
<td>294</td>
<td>14,153</td>
<td>-15,081</td>
</tr>
</tbody>
</table>


According to this table, introducing potatoes into the portfolio of crops is an optimal strategy because it increases the gross margin of the portfolio. In addition, while potatoes can be considered as a risky crop due to its large variance in gross margin in relation to traditional crops, it can still contribute in the reduction of the total business risk of the portfolio. This is because the gross margin of potatoes is negatively correlated with that of traditional crops implying that the elimination of this crop not only reduces the expected gross margin of the portfolio of crops, but also increases its business risk.

In terms of the Miles and Snow’s typology, these farmers were classified as defenders. This is because these individuals made a suboptimal decision with the purpose of maintaining their competitive position in the market of traditional crops with low levels of gross margin. This suboptimal decision led them to achieve a portfolio of crops with lower level of gross margin and higher levels of business risk.

d) **Class 4: Progressive risk enlarger (PRE)**

This class is characterised by individuals who chose a portfolio of crops achieving higher levels of gross margin and higher levels of business risk in response to an exogenous shock. The changes of gross margin and business risk of the portfolios of crops chosen by these farmers are shown Table 7.11:
Table 7.11 Changes of gross margin and business risk of the portfolios of crops chosen by the PRE.

<table>
<thead>
<tr>
<th>Observation (i)</th>
<th>dGM&lt;sub&gt;i&lt;/sub&gt; (£/ha)</th>
<th>dBRI&lt;sub&gt;i&lt;/sub&gt; (square of £/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,323.75</td>
<td>115,423.50</td>
</tr>
<tr>
<td>3</td>
<td>1,106.19</td>
<td>328,928.10</td>
</tr>
<tr>
<td>6</td>
<td>1,031.11</td>
<td>466,825.20</td>
</tr>
<tr>
<td>8</td>
<td>168.23</td>
<td>5,139.30</td>
</tr>
<tr>
<td>24</td>
<td>2,253.72</td>
<td>465,142.10</td>
</tr>
<tr>
<td>25</td>
<td>1,527.38</td>
<td>76,878.52</td>
</tr>
<tr>
<td>27</td>
<td>1,028.39</td>
<td>155,923.30</td>
</tr>
<tr>
<td>37</td>
<td>1,765.53</td>
<td>288,946.50</td>
</tr>
<tr>
<td>42</td>
<td>1,644.82</td>
<td>219,529.60</td>
</tr>
<tr>
<td>45</td>
<td>1,956.67</td>
<td>379,680.00</td>
</tr>
<tr>
<td>46</td>
<td>4,062.37</td>
<td>839,439.90</td>
</tr>
</tbody>
</table>

The information presented in this table was plotted in the following figure:

Figure 7.7 Changes of expected gross margin and business risk in response to the removal of material resource barriers: the case of the PRE.
As shown in this figure, the PRE are located in Quadrant I meaning that all these individuals chose portfolios of crops achieving higher levels of expected gross margin (i.e. \(d\text{GM}_i > 0\)) and business risk (\(d\text{BR}_i > 0\)). In contrast to the cases depicted in Figures 7.5 and 7.6, the PRE did not follow a clear pattern suggesting that individuals who did not follow the EPL made strategic decisions that depended on their particular situation. Some particular situations identified in this research are described as follows.

Two groups of farmers fell into the PRE class: all the farmers who departed from the EPL after the technological shock; and observations 8 and 37 (i.e. the farmers who were outliers before and after the incidence of the shock). Regarding the first group of farmers, 33% of these individuals adjusted to the exogenous shock by introducing new crops with very high gross margin and a very high degree of risk into their portfolios. Examples of these crops are carrots, parsnips, strawberries and raspberries. The other 67% of these farmers replaced one or more crops with low gross margin with one of these enterprises. In terms of the Miles and Snow’s typology, all these farmers were classified as prospectors because they were able to innovate by means of the incorporation of riskier crops with higher levels of gross margin in response to the exogenous shock.

Regarding observation 8, on the other hand, this farmer used to be located to the right of the EPL before the exogenous shock. The reason for this is that this farmer was able to produce carrots before the incidence of the technological shock. That is, this farmer was able to form a portfolio of crops with high level of expected gross margin even before the shock. It is for this reason that it was difficult for this individual to increase significantly the level of gross margin by diversifying. This explains why the gain in
gross margin after the shock was moderate for this farmer even when introducing parsnips as a new enterprise in response to the exogenous shock.

Farmer 37, in contrast, used to be an outlier located to the left of the EPL before the technological shock. This is because this individual chose a portfolio comprising only crops with low levels of gross margin. In addition, this farmer rented a significant proportion of land and was receiving an income for the land that was almost free of risk. As a consequence, the adoption of carrots in response to the exogenous shock strongly increased the level of gross margin and business risk of the new portfolio chosen by this individual. In terms of the Miles and Snow’s typology, both farmers were classified as prospectors because both of them introduced innovative alternatives with high levels of business risk and gross margin in response to the technological shock.

e) Class 5: Regressive risk enlarger (RRS)

Only observation 32 was included in this class (i.e. the farmer who was an outlier before but not after the incidence of the shock). This is because this farmer chose a portfolio of crops achieving a lower level of gross margin and a lower level of business risk in response to the exogenous shock. The changes in gross margin and business risk of the portfolio of crops chosen by this individual are shown in Table 7.12:
Table 7.12 Changes of gross margin and business risk of the portfolios of crops chosen by the RRS.

<table>
<thead>
<tr>
<th>Observation (i)</th>
<th>dGM&lt;sub&gt;i&lt;/sub&gt; (£/ha)</th>
<th>dBRR&lt;sub&gt;i&lt;/sub&gt; (square of £/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>-447.39</td>
<td>-15,127.60</td>
</tr>
</tbody>
</table>

This information was plotted in the following figure:

Figure 7.8 Changes of expected gross margin and business risk in response to the removal of material resource barriers: the case of the RRS.

According to the definition of RRS farmers, these individuals are presented in Quadrant III meaning that these individuals adjust in response to exogenous shocks by selecting portfolios of crops achieving lower levels of expected gross margin (i.e. dGM<sub>i</sub> < 0) and lower levels of business risk (i.e. dBRR<sub>i</sub> < 0). This is the case presented Quadrant III of Figure 7.8 which corresponds to Observation 32. As shown in Table 7.12 and Figure 7.8, the level of expected gross margin of the new portfolio of crops chosen by this
individual decreased by $d_{GM} = -£447.39/ha$ and the level of business risk of this portfolio decreased by $d_{BR} = £215,127.6/ha^2$.

According to the Miles and Snow’s typology this farmer was classified as a reactor because this individual eliminated crops with high levels of gross margin and business risk in response to the technological shock. This is why the new portfolio of crops chosen by this farmer achieved lower levels of these variables (i.e. $d_{GM} < 0$ and $d_{BR} < 0$) This result is even more counterintuitive when considering the fact that this individual had a farm shop where he would sell his products and that he therefore had an ensured clientele for his products.

Table 7.13 summarises the classes and subclasses of farmers identified in this section. It also shows the strategies adopted by them in response to the technological shock.
Table 7.13 Farmers’ classification according to their strategic responses to the shock

<table>
<thead>
<tr>
<th>Class of Farmers</th>
<th>Subclasses of Farmers</th>
<th>Strategy adopted after the shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1: NF</td>
<td>Subclass 1.1: Defender</td>
<td>Chose the same crops</td>
</tr>
<tr>
<td></td>
<td>Subclass 1.2: Analysers</td>
<td>Partial innovation into crops with low gross margin</td>
</tr>
<tr>
<td>Class 2: PRS</td>
<td>Subclass 2.1: Defender</td>
<td>Chose the same crops, or eliminated traditional crops</td>
</tr>
<tr>
<td></td>
<td>Subclass 2.2 Analysers</td>
<td>Partial innovation into a crop with high gross margin (potatoes)</td>
</tr>
<tr>
<td>Class 3: RRE</td>
<td>Subclass 3.1: Defender</td>
<td>Eliminated a crop with high gross margin to maintain the competitive position in the market of traditional crops</td>
</tr>
<tr>
<td>Class 4: PRE</td>
<td>Subclass 4.1: Prospector</td>
<td>Incorporated crops with very high gross margin</td>
</tr>
<tr>
<td>Class 5: RRS</td>
<td>Subclass 5.1: Reactor</td>
<td>Eliminated crops with very high gross margin</td>
</tr>
</tbody>
</table>

This table reveals an important fact that was discussed at the beginning of the present chapter. This is that the Miles and Snow’ typology cannot capture some strategic choices that farmers might eventually adopt in response to an exogenous shock. For example, the table shows that three types of defender farmers were identified in the simulation: NF; PRS; and RRE. This finding suggests that the proposed Income-Risk Matrix criterion provides a more accurate description of farmers’ strategic behaviour. Moreover, this criterion can be used as a complement to the Miles and Snow’ typology because this permits identifying subclasses of farmers as shown in Table 7.13. Finally,
the classification presented in this table was used to identify the non-economic drivers that explained the different strategic choices adopted by farmers belonging to different classes. This analysis is presented in next section.

7.2.3 Non-economic Drivers Explaining Differences among Classes of Farmers

What is surprising about the analysis conducted in Sections 7.2.1 and 7.2.2 is that only few individuals behaved as PRS and PRE as predicted by the MEFT. However, other farmers responded by behaving in a different way than that predicted by this theory. In fact, five classes of farmers were identified in terms of the Income-Risk matrix typology: NF; PRS; PRE; RRS; and RRE. It was concluded from this result that the ESBF not only considered economic variables in response to the exogenous shock, but also non-economic drivers. That is, it was concluded that deviations from the predictions obtained from the MEFT were caused by the incidence of non-economic drives that influenced farmers’ strategic decisions.

The aim of the present section was to identify these non-economic drivers that explained why the farmers in the sample behaved either as NF, PRS, RRE, PRE or RRS. For this purpose, the sample mean of the variables and statements presented in the questionnaire for each of these types of farmers was compared (see Appendix L). Only variables and statements that were significant according to the Student $t$ test criterion were considered. The results are described below.

Before presenting the results obtained in this section, however, it is important to clarify that a graphical strategy was adopted with the purpose of explicitly showing the link between these results and the MEFT proposed in this thesis. This graphical strategy was
useful to visually show how and why individuals deviated from the predictions obtained by the MEFT. The derivation of this graphical strategy is explained as follows.

According to the MEFT, only two classes of farmers can be found in terms of their behavioural responses to the removal of material resource restrictions (i.e. exogenous shock). These responses were formalised in two hypotheses: the HAE which postulates that farmers who also face market barriers preventing them from adopting crops with high gross margin adjust to the shock by moving upwards along the EPL; and the HAD which postulates that farmers who do not face market barriers adjust by departing from the EPL. In order to explain this idea in more detail, consider Figure 7.9.

![Figure 7.9 Possible strategies adopted by a farmer in response to a removal of material resource barriers.](image-url)
Suppose that before the removal of material resource barriers, a farmer was located at point \( a \) on the \( EPL \) depicted in red in Figure 7.9. In other words, this individual maximised his/her expected utility at point \( a \) where the indifference curve \( E(U(\pi)_0 \) (i.e. the straight line in blue) is at this point tangent to the efficient frontier \( EF_0 \) (i.e. the bent curve in blue). What would be the optimal choice of this individual if all material resource restrictions were removed? According to the MEFT, this would depend on whether this farmer also faced market barriers preventing him/her from producing crops with high levels of expected gross margin. In particular, if this individual not only faced material resource barriers but also market barriers, then the removal of the former would not help this farmer to adopt crops with higher levels of gross margin because he/she would still be facing market barriers. Nonetheless, this individual could still improve his/her position on the \( EPL \) because the removal of material resource barriers would help this farmer to produce traditional crops more efficiently. For example, this could be achieved by incorporating newer and more efficient machinery. As a consequence, this individual would be able to form a portfolio of crops that would help him/her to achieve higher levels of expected gross margin per unit of business risk. This case is shown in Figure 7.9 as a movement upwards along the \( EPL \) from point \( a \) to point \( b \). In other words, the removal of material resource barriers helped this individual to increase the level of expected gross margin from \( E(\pi)_0 \) to \( E(\pi)_1 \) and to reduce business risk from \( V(\pi)_0 \) to \( V(\pi)_1 \). This was achieved by maximising his/her expected utility at point \( b \), where the indifference curve \( E(U(\pi))_1 \) (i.e. the straight line in green) is at this point tangent to the efficient frontier \( EF_1 \) (i.e. the bent curve in green). On the other hand, if this individual only faced material resource barriers but not market barriers preventing him/her from producing crops with high levels of gross margin, then the removal of the former would allow this individual to introduce these crops into the portfolio. But because crops with high levels of gross margin have also high levels of business risk,
the resulting portfolio would also have higher levels of expected gross margin and business risk. This additional business risk can be tolerated as long as the increment in expected gross margin is large enough to generate a net gain in expected utility when forming the new portfolio. This case is shown in point $c$ in figure 7.9. In this case, the removal of material resource barriers permitted the farmer to increase the level of expected gross margin from $E(\pi)_0$ to $E(\pi)_2$ and this was accompanied by an increase in the level of business risk from $V(\pi)_0$ to $V(\pi)_2$. The net effect was an increment of expected utility from $E(U(\pi))_0$ to $E(U(\pi))_2$. In figure 7.9, this was achieved in point $c$ where the indifference curve $E(U(\pi))_2$ (i.e. the straight line in purple) is at this point tangent to the efficient frontier $EF_2$ (i.e. the bent curve in purple). Note that this individual also had the choice to form a portfolio composed only of traditional crops in order to maximise expected utility at point $b$. However, because the level of expected utility is higher at point $c$ (i.e. $E(U(\pi))_2 > E(U(\pi))_1$), the best strategy for this individual was to introduce crops with high levels of gross margin in order to reach this point.

The graphical strategy adopted to link the results obtained in this section with the MEFT is derived from Figure 7.9. This corresponds to a simplified representation which only considers the $EPL$ and the choice made by the farmers. This simplification was useful to compare different strategies adopted by different farmers (i.e. NF; PRS; PRE; RRS; and RRE) without losing generality. In order to understand this simplification, consider again the two strategies described in Figure 7.9 (i.e. movement from point $a$ to $b$; and the movement from point $a$ to $c$). These strategies are shown in the following simplified version of this figure.
As discussed above, the MEFT postulates that a farmer who faces both material resource restrictions and market barriers will adjust in response to a removal of the former by choosing a portfolio of crops consistent with point $b$ in Figure 7.10. This is captured as a movement upwards along the EPL (this movement is represented by the blue arrow). This prediction was formalised as the hypothesis of adaptation along the EPL, HAE. According to the Income-Risk Matrix typology (see Figure 4.17 and Table 7.13), farmers who adopt this strategy are classified as PRS. On the other hand, the MEFT postulates that farmers who only face material resource barriers will adjust to the removal of these barriers by choosing a portfolio of crops consistent with point $c$ in Figure 7.10. This is captured as a movement that departs from the EPL (this movement is represented by the purple arrow). This prediction was formalised as the hypothesis of adaptation by departing from the EPL, HAD. According to the Income-Risk Matrix typology, farmers who adopt this strategy are classified as PRE.
Figure 7.10 is an example of the graphical representation adopted in this section. This figure is used as a benchmark for the analysis that follows because it only shows the movements that were predicted by the MEFT (i.e. a movement from point $a$ to point $b$ which is considered by the HAE; and a movement from point $a$ to point $c$ which is considered by the HAD). Consequently, any movement different from those shown in this figure can be considered as a deviation from this theory.

In order to use this graphical tool to compare different groups of farmers, the averages of the expected gross margin and the averages of business risk achieved by these groups before and after the removal of material resource barriers were considered. This information is presented in the following table:

Table 7.14: Average of expected gross margin and business risk of the groups of farmers identified in the research.

<table>
<thead>
<tr>
<th>Group of Farmer</th>
<th>Average of Expected Gross Margin (£/ha)</th>
<th>Average of Business Risk (Variance of Gross Margin) (Square £/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before Shock</td>
<td>After Shock</td>
</tr>
<tr>
<td>NF</td>
<td>378</td>
<td>376</td>
</tr>
<tr>
<td>PRS</td>
<td>426</td>
<td>607</td>
</tr>
<tr>
<td>PRE</td>
<td>515</td>
<td>2,286</td>
</tr>
<tr>
<td>RRS</td>
<td>1,079</td>
<td>631</td>
</tr>
<tr>
<td>RRE</td>
<td>635</td>
<td>338</td>
</tr>
</tbody>
</table>

The strategies adopted by these farmers in response to this shock are indicated with arrows as shown in Figure 7.10. Let us now consider the results.
a) A Comparison of Classes 1 and 2

An interesting characteristic of the farmers that were classified as class 1 (i.e. NF farmers) and 2 (i.e. PRS farmers) is that all of them were found to be non-outlier farmers (i.e. farmers who remained on the EPL after the introduction of the technological shock). Because this finding did not support the HAE, it was concluded that the strategies adopted by these individuals were different as a consequence of the existence of one or more non-economic drivers that influenced their strategic behaviour. This was indeed verified by the data. Table 7.15 shows that one non-economic driver was found to be significant in explaining this difference. This table is presented as follows.

Table 7.15 Non-economic drivers explaining behavioural differences between NR and RRS farmers.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Answer Class 1 (NF)*</th>
<th>Answer Class 2 (PRS)*</th>
<th>t**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retailers demand a volume that I cannot produce</td>
<td>3.81</td>
<td>2.93</td>
<td>2.39</td>
</tr>
</tbody>
</table>

*Farmers used the following 5-points Likert scale to indicate the importance that they assigned to non-economic drivers (statements): (1) strongly disagree; (2) disagree; (3) indifferent; (4) agree; and (5) disagree.

**Student t critical value for 30 degrees of freedom at the 5% level of significance: 2.042

This result suggests that the NF farmers were not necessarily willing to maintain a constant level of gross margin and business risk in response to the exogenous shock. On the contrary, it appears that they did not choose portfolios of crops with higher levels of expected gross margin because they did not have the productive capacity to fill the demand required by relevant retailers. In contrast, the PRS farmers increased the level of expected gross margin of their portfolios by adopting potatoes as an additional crop. This result indicates, therefore, that the removal of material resource barriers could only
favour those farmers who have the productive capacity to satisfy retailers’ demand. If farmers did not have this capacity, then they would behave as NF.

Let us now link this result with the MEFT. For this purpose, consider the following figure:

![Figure 7.11 Strategic choices made by the NF and PRS.](image)

In this figure, the red point $a$ corresponds to the combination of expected gross margin and variance of gross margin that the PRS farmer achieved on average before the removal of material resource barriers. The red point $b$ corresponds to the combination of expected gross margin and variance of gross margin that the PRS farmer achieved on average after the shock. The blue point $c$ corresponds to the combination of expected gross margin and variance of gross margin that the NF farmer achieved on average before the removal of material resource barriers. Finally, the blue point $d$ corresponds to
the combination of expected gross margin and variance of gross margin that the NF farmer achieved on average after the shock.

A comparison between this figure and Figure 7.10 reveals that only the group of PRS behaved as predicted by the MEFT. This is because they adjusted by moving along the \( EPL \) from point \( a \) to point \( b \). However, the NF remained in the same relative position (points \( c \) and \( d \)). Because this latter strategy was not predicted by the MEFT, it is concluded therefore that lack of productive capacity is a factor that can generate deviations from the theory. In this particular case, the NF did not behave as predicted by the MEFT because they faced capacity constraints that prevented them from moving upwards along the \( EPL \) in order to fill retailers’ demands.

b) A Comparison of Classes 1 and 3

Class 3 (i.e. RRE farmers) is the third group of non-outlier farmers that were identified in the current research and corresponds to the individuals whose strategy was the formation of portfolios of crops achieving lower levels of gross margin and higher levels of business risk. A statistical analysis between Classes 1 and 3 was conducted with the objective of determining whether their strategic behavioural differences were explained by the existence of non-economic drivers. According to Table 7.16, three non-economic drivers were found to be significant in explaining these differences. This table is presented as follows.

336
Table 7.16 Non-economic drivers explaining behavioural differences between NR and RRE farmers.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Answer Class 1 (NF)*</th>
<th>Answer Class 3 (RRE)*</th>
<th>t**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoy my work</td>
<td>4.38</td>
<td>5.00</td>
<td>-2.38</td>
</tr>
<tr>
<td>Provide for next generations</td>
<td>4.19</td>
<td>3.25</td>
<td>3.04</td>
</tr>
<tr>
<td>Age</td>
<td>54.7</td>
<td>41.8</td>
<td>2.31</td>
</tr>
</tbody>
</table>

*Farmers used the following 5-points Likert scale to indicate the importance that they assigned to non-economic drivers (statements): (1) strongly disagree; (2) disagree; (3) indifferent; (4) agree; and (5) disagree.

**Student t critical value for 18 degrees of freedom at the 5% level of significance: 2.101

The interpretation given to these results is presented as follows. It appears that the RRE followed a suboptimal choice (see Table 7.13) because they were younger and, therefore, less experienced; willing to enjoy their work by not choosing time demanding activities; and less worried about future generations. In contrast, the NF farmers were more interested in maintaining their current levels of gross margin in order to ensure a minimum provision for next generations even if this meant they had to work in a less enjoyable environment.

Let us now link these results with the MEFT. For this purpose, consider the following figure:
According to this figure, none of these groups of farmers behaved as predicted by the MEFT (see Figure 7.10). As discussed in point (a) above, the NF farmers were unable to reach a better position on the *EPL* because they faced capacity constraint. Nonetheless, maintaining their competitive position on this line allowed these individuals to ensure a minimum provision for next generations. In contrast, the RRE farmers moved downwards along the *EPL* from point *a* to point *b* reflecting the fact that these individuals were younger, less experienced, less worried about next generations, and more interested in enjoying their works. This result suggests, therefore, that deviation from the MEFT can also occur when farmers have these characteristics. In other words, suboptimal decisions made by young people with lack of experience and who care more about enjoying their work rather than future generations is captured as a deviation from the behaviour described in Figure 7.10.
c) A Comparison of Classes 2 and 3

According to Table 7.17, two non-economic drivers proved to be significant in explaining why farmers of classes 2 and 3 chose different strategies in response to the technological shock. This table is presented as follows.

Table 7.17 Non-economic drivers explaining behavioural differences between RRE and PRS farmers.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Answer Class 2 (PRS)*</th>
<th>Answer Class 3 (RRE)*</th>
<th>t**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoy my work</td>
<td>4.25</td>
<td>5.00</td>
<td>2.55</td>
</tr>
<tr>
<td>Age</td>
<td>53.4</td>
<td>41.8</td>
<td>-2.62</td>
</tr>
</tbody>
</table>

*Farmers used the following 5-points Likert scale to indicate the importance that they assigned to non-economic drivers (statements): (1) strongly disagree; (2) disagree; (3) indifferent; (4) agree; and (5) disagree.

**Student t critical value for 18 degrees of freedom at the 5% level of significance: 2.101

Because these results are closely related to those obtained for the case of classes 1 and 3, the same arguments given in that case were adopted to explain the strategic behavioural differences between farmers of classes 2 and 3 (see part b above). The link of this result with the MEFT is shown in the following figure.
According to this figure, only the PRS farmers behaved as predicted by the MEFT because they moved upwards along the $EFL$ from point $c$ to point $d$ (see Figure 7.10). In contrast, the RRE farmers made a suboptimal decision which, according to Table 7.17, is explained by the fact that these individuals were younger (apparently reflecting lack of experience) and more interested in enjoying their work than the PRS farmers (this result is closely related to that described in point (b) above). This advocates, therefore, that achieving a better position on the $EPL$ could not necessarily be enjoyable and requires some levels of experience. This impressive result suggests, therefore, that there existed a trade-off between making optimal decisions and work enjoyment for farmers who made decisions along the $EPL$. Consequently, another factor that could cause deviations from the MEFT is farmers’ unwillingness to give up enjoying their work.
d) A Comparison of Classes 1 and 4

The behavioural response of the farmers classified as Class 4 (i.e. the PRE farmers) was consistent with the strategic behaviour predicted by the MEFT. This is because these farmers chose a portfolio of crops that achieved higher levels of gross margin and higher levels of business risk after the introduction of the exogenous shock. This is why the HAD was supported by the data (see Section 7.2.1).

It is important to identify, nonetheless, what made these farmers behave in a predictable way in comparison with the non-outlier farmers. For this purpose, a statistical analysis was developed to identify possible non-economic drivers explaining why farmers in Classes 1 and 4 chose different strategies in response to the exogenous shock. According to Table 7.18, four non-economic drivers were found to be significant in explaining this difference. This table is presented as follows.

Table 7.18 Non-economic drivers explaining behavioural differences between NF and PRE farmers.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Answer Class 1 (NF)*</th>
<th>Answer Class 4 (PRE)*</th>
<th>t**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belonging to the farming community</td>
<td>3.63</td>
<td>4.27</td>
<td>-2.22</td>
</tr>
<tr>
<td>Farming is still fun and satisfying</td>
<td>3.31</td>
<td>4.09</td>
<td>-2.32</td>
</tr>
<tr>
<td>Legislation spoils the pleasure in my work</td>
<td>4.56</td>
<td>4.00</td>
<td>2.55</td>
</tr>
<tr>
<td>I am not familiar with the productive process of crops with high gross margin</td>
<td>3.75</td>
<td>3.09</td>
<td>2.11</td>
</tr>
</tbody>
</table>

*Farmers used the following 5-points Likert scale to indicate the importance that they assigned to non-economic drivers (statements): (1) strongly disagree; (2) disagree; (3) indifferent; (4) agree; and (5) disagree.

**Student $t$ critical value for 25 degrees of freedom at the 5% level of significance: 2.06
These results suggest that the PRE group were more willing to adopt a prospector strategy as a result of a combination of motivational factors. That is, these farmers were more satisfied with farming activity and more interested in belonging to the farming community. In addition, pleasure in work was less negatively affected by legislation in the case of the PRE farmers. This indicates that farmers who felt farming was fun and satisfying were more motivated to innovate by introducing crops with higher levels of gross margin. By contrast, farmers who were less satisfied in their places of work were less motivated to innovate, a fact that can explain why the NF farmers were not familiar with the productive process of crops with high levels of gross margin. In order to link this result with the MEFT, consider the following figure.

![Figure 7.14 Strategic choices made by the NF and PRE.](image-url)
According to this figure, the PRE farmers strongly deviated from the EPL as predicted by the theory (see Figure 7.10). As discussed above, this could reflect two facts. Firstly, these farmers only faced material resource barriers that prevented them from adopting crops with high levels of gross margin. As a consequence, the removal of these barriers allowed them to introduce these crops into their portfolios achieving, by this way, very high levels of expected gross margin. This improvement in terms of the level of gross margin was reflected in Figure 7.14 as a dramatic movement from point a to b. In contrast, as discussed in point (a) above, the NF faced capacity constraint that prevented them from filling retailers’ demand. This can explain why they did not introduce crops with high gross margin in their portfolios. That is, this explains why these farmers remained in the same point in Figure 7.14. Secondly, the optimal choice made by the PRE farmers is not only explained by the fact that these individuals did not face market barriers. On the contrary, motivational factors associated with farming community involvement, satisfaction, and knowledge apparently played an important role in this choice. This suggests, therefore, that deviations from the MEFT could be found in farmers who do not consider these motivational factors.

e) A Comparison of Classes 2 and 4

Farmers that were classified as Class 2 (i.e. the PRS farmers) and Class 4 (i.e. the PRE farmers) chose portfolios of crops that allowed them to increase the levels of gross margin in response to the technological improvement. However, the PRS farmers were able to increase gross margin by innovating in crops that decreased the level of business risk of their portfolios. In contrast, the PRE were able to increase gross margin by
innovating in crops that increased business risk. According to Table 7.19, four non-economic drivers were found to be significant in explaining these differences.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Answer Class 2 (PRS)*</th>
<th>Answer Class 4 (PRE)*</th>
<th>t**</th>
</tr>
</thead>
<tbody>
<tr>
<td>I take challenges more often than other farmers</td>
<td>3.19</td>
<td>3.82</td>
<td>-2.15</td>
</tr>
<tr>
<td>I use my equity capital as a risk buffer</td>
<td>3.69</td>
<td>3.09</td>
<td>2.17</td>
</tr>
<tr>
<td>Legislation spoils the pleasure in my work</td>
<td>4.69</td>
<td>4.00</td>
<td>3.22</td>
</tr>
<tr>
<td>Producing these crops implies collaborative alliances that are difficult to form</td>
<td>3.75</td>
<td>3.00</td>
<td>2.20</td>
</tr>
</tbody>
</table>

*Farmers used the following 5-points Likert scale to indicate the importance that they assigned to non-economic drivers (statements): (1) strongly disagree; (2) disagree; (3) indifferent; (4) agree; and (5) disagree.

**Student t critical value for 25 degrees of freedom at the 5% level of significance: 2.06

It is possible to identify from these results that three main factors influenced the cropping decisions of these farmers in response to the exogenous shock. The first factor was related to the attitudes of these individuals towards risk. In particular, it is possible that the PRE became less risk averse after the introduction of the exogenous shock. This is referred to as Decrease Absolute Risk Aversion (DARA) and is a phenomenon that occurs when the levels of income increases. That is, individuals become more likely to be risk takers when they obtain higher levels of income in conditions of uncertainty (Jehle and Reny, 2001). Because the levels of gross margin of the portfolios of crops chosen by the PRE strongly increased after the shock, it is not surprising then that these individuals became less risk averse. Actually, this phenomenon has been detected by
some researchers studying farmers’ attitudes towards risk (see, for example, Bar-Shira et al., 1997; and Pope and Just, 1991). This can explain why the PRE farmers assigned a higher importance to the statement “I take challenges more often than other farmers” and a lower importance to the statement “I use my equity capital as a risk buffer”. That is, because the PRE farmers became less risk averse after the incidence of the technological shock, they were more willing to take risks than the PRS farmers. Likewise, because the former farmers became less risk averse, they were less interested in using their capital as a risk buffer.

The second factor that influenced the strategic behaviour of these farmers was motivational. This can be inferred from the fact that pleasure at work was less affected by legislation in the case of the PRE farmers. As a consequence, they were still motivated by working in the farm and this probably positively affected their willingness to innovate in riskier enterprises. Finally, the third factor that influenced the cropping decisions of these farmers was the opportunity to form collaborative alliances. It appears that innovation in riskier crops with higher levels of gross margin required the ability to form these alliances. This was in fact supported by the opinion given by one of the farmers in the sample. According to this individual, collaboration allowed him to enter to a particular market for carrots.

Let us now link these results with the MEFT. For this purpose, consider the following figure:
This figure is the only one that is consistent with Figure 7.10 because it reflects the predictions obtained from the MEFT. This is because one group of farmers (PRS) improved their competitive position by moving upwards from the EPL from point $a$ to point $b$ as predicted by the HAE. The PRE farmers, in contrast, were able to improve their competitive position by departing from the EPL from point $c$ to point $d$ as predicted by the HAD. The MEFT postulates that the difference between these strategic choices reflects the fact that the PRE do not face market barriers preventing them from adopting crops with high gross margin. This was confirmed by the results. As shown in Table 7.19, the barrier that prevented the PRS farmers from producing these crops was the difficulty to form collaborative alliances. This is because these alliances allow farmers to share productive costs, to share resources and to increase the volume of production needed to satisfy retailers’ demand. Note, however, that this was not the only factor explaining the different choices made by the PRS and PRE farmers. Apparently, note that the HAE only held for this fraction of farmers who remained in the EPL after the shock. However, this was not a common response as discussed in this chapter.
farmers who were more willing to take challenges and more motivated in terms of developing innovative activities were more inclined to behave as PRE. Conversely, farmers who were less willing to take challenges and to innovate were more inclined to behave as PRS.

f) A Comparison of Classes 3 and 4

Farmers that were classified as class 3 (i.e. the RRE farmers) and class 4 (i.e. the PRE farmers) chose portfolios of crops achieving higher levels of business risk in response to the exogenous shock. However, they differed in that the RRE farmers obtained lower levels of gross margin after the shock, whilst the PRE obtained higher levels of gross margin. According to Table 7.20, one non-economic driver was found to be significant in explaining this difference. This table is shown as follows.

Table 7.20 Non-economic drivers explaining behavioural differences between RRE and PRE farmers.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Answer Class 3 (RRE)*</th>
<th>Answer Class 4 (PRE)*</th>
<th>t**</th>
</tr>
</thead>
<tbody>
<tr>
<td>I enjoy having a purpose and value hard work</td>
<td>3.75</td>
<td>4.54</td>
<td>-2.63</td>
</tr>
</tbody>
</table>

*Farmers used the following 5-points Likert scale to indicate the importance that they assigned to non-economic drivers (statements): (1) strongly disagree; (2) disagree; (3) indifferent; (4) agree; and (5) disagree.

**Student t critical value for 25 degrees of freedom at the 5% level of significance: 2.16

This result suggests that these farmers chose different strategies because they had different valuations of hard work. That is, since producing crops with high gross margin is time demanding, and because the PRE assigned higher importance to hard work, it is not surprising that these individuals were willing to adopt these crops.
In order to link this result with the MEFT, consider the following figure:

![Graph showing strategic choices](image)

Figure 7.16 Strategic choices made by the RRE and PRE.

A comparison between this figure and Figure 7.10 revealed that only the PRE farmers behaved as predicted by the MEFT because they improved their competitive position relative to the EPL by moving from point $a$ to point $b$. In contrast, the RRE made a suboptimal choice because they chose portfolios of crops achieving on average lower levels of expected gross margin and higher levels of business risk in response to the removal of material resource barriers (i.e. they moved from point $c$ to point $d$ along the EPL). In order to understand these different strategic choices, remember that it was discussed in Case $c$ above that the RRE farmers are individuals who cared about enjoying their work. Apparently, these individuals faced a trade-off between work enjoyment and hard work. The same situation is reflected in the present case. That is, departing from the EPL in order to reach a better competitive position demands hard
work because this can be achieved by adopting very time demanding crops with high levels of expected gross margin. Because the PRE farmers valued hard work as shown in Table 7.20, this positive attitude towards hard work explains why these individuals adopted crops with high levels of expected gross margin. This, in turn, allowed these individuals to reach a better competitive position that is consistent with the HAD. In contrast, because the RRE considered hard work less enjoyable, and because they faced a trade-off between hard work and work enjoyment, they adopted a suboptimal decision in order to favour work enjoyment. In terms of the MEFT, this result suggests that deviations from the predictions obtained from this theory can be found in cases where farmers do not value hard work.

g) The Case of Class 5

This class is characterised by farmers who chose portfolios of crops achieving lower levels of both gross margin and business risk in response to exogenous shocks (i.e. RRS farmers). Only one farmer was included in this class. This case is very interesting because this individual was one of the successful outliers who had diversified his productive plan by means of the adoption of carrots, parsnips, strawberries and raspberries. What is interesting about this farmer is that he eliminated all these crops in response to the exogenous shock. As a result, he obtained a portfolio with a much lower level of expected gross margin. Moreover, this strategy allowed him to reach a position on the EPL. Unfortunately it was not possible to identify with certainty which non-economic drivers explain why this farmer adopted this strategy in response to the shock as this individual was the only farmer included in class 5. As a consequence, it was not possible to use the Student t test criterion to compare this class with the other classes identified in the research.
It is for this reason that a simple comparison between classes 4 (i.e. PRE) and 5 was considered. The idea was to identify some differences between these farmers that could eventually explain why the RRS farmer chose a different strategy. Class 4 was selected for this simple comparison because the strategy adopted by farmers in this class was exactly the opposite to that adopted by the farmer in class 5. This comparison is presented in table 7.21.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Class 4 (PRE)*</th>
<th>Class 5 (RRS)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialisation in order to obtain high production</td>
<td>3.18</td>
<td>5.00</td>
</tr>
<tr>
<td>I am not interested in other alternatives</td>
<td>2.36</td>
<td>5.00</td>
</tr>
<tr>
<td>Have the control in a variety of situations</td>
<td>4.55</td>
<td>3.00</td>
</tr>
</tbody>
</table>

*Farmers used the following 5-points Likert scale to indicate the importance that they assigned to non-economic drivers (statements): (1) strongly disagree; (2) disagree; (3) indifferent; (4) agree; and (5) disagree.

This table shows that three variables seemed to explain why the RRS farmer adopted a different strategy with respect to the PRE farmers. One of them was attitude towards the strategy “specialisation in order to obtain high production”. According to the table, the RRS assigned a score equal to 5.0 in the 5-point Likert scale to this statement meaning that this farmer strongly agreed to this strategy. In contrast, the PRE farmers assigned on average a score equal to 3.18 meaning that these individuals were indifferent to this statement. This comparison suggests that the RRS decided to eliminate crops with high gross margin from his portfolio in order to become more efficient and to obtain higher production of traditional crops.
This is also supported by the second comparison presented in Table 7.21 which focuses on the statement “I am not interested in other alternatives”. According to this table, the RRS assigned a score equal to 5.0 on the 5-point Likert scale to this statement meaning that this farmer strongly agreed to this strategy. In contrast, the PRE farmers assigned on average a score equal to 2.36 meaning that these individuals disagreed to the statement. This suggests that the RRS farmer was not satisfied with the business even when he was successful.

A possible explanation for this finding is that this individual was not really the person who introduced innovations in the business. The innovator was his father who is now retired. When this individual was working in the farm before retiring, he diversified the business by incorporating crops with high levels of gross margin such as carrots, parsnips, strawberries and raspberries. In order to ensure a demand for these products, this farmer also established a farm shop next to the farm. The low gross margin choice made by the RRS farmer suggests that this individual did not identify with the achievements obtained by his father and had objectives other than running the business.

In this context, specialising in the production of traditional crops in response to the exogenous shock would give him the opportunity to gain efficiency and to enjoy more free time. This is because the production of these crops is less time demanding and requires less control of the business than crops with high levels of gross margin. This reasoning is supported by the score that this individual assigned to the statement “have the control in a variety of situations”. According to Table 7.21, the RRS assigned a score equal to 3.0 in the 5-point Likert scale to this statement meaning that this farmer
was indifferent to this goal. In contrast, the PRE farmers assigned on average a score equal to 4.55 meaning that these individuals strongly agreed with this statement.

In order to link these results with the MEFT, consider the following figure:

![Figure 7.17 Strategic choices made by the RRS and PRE.](image)

This figure shows that only the PRE farmers behaved as predicted by the MEFT because these individuals improved their competitive position by moving from point \(a\) to point \(b\) which is consistent with the HAD (see Figure 7.10). However, the RRS farmer adopted the opposite strategy because this individual moved from a better competitive position (point \(c\)) to a less competitive position (point \(d\)) in response to the removal of material resource barriers. As discussed above, this result reflects an important motivational factor. That is, the RRS farmer apparently did not feel identified with the farm because the achievements and successful innovations were made by his father but not by himself. This finding suggests therefore that lack of motivation can
also generates deviations from the predictions obtained from the MEFT. This is because this theory predicts farmers’ optimal behaviour. However, lack of motivation could lead to suboptimal decisions as the one adopted by the RRS farmer shown in Figure 7.17.

### 7.2.4 Non-economic Drivers Explaining Differences among Subclasses of Farmers

The classification presented in Table 7.13 shows that some classes of farmers were subdivided into two subclasses. For example, Class 1 (i.e. NF farmers) was subdivided into Subclass 1.1 (i.e. NF defender farmers) and Subclass 1.2 (i.e. NF analyser farmers). These subclasses reflect different strategies made by NF farmers to achieve the same goal: to maintain the same levels of expected gross margin and business risk after the incidence of the shock. The NF defender farmers achieved this goal by changing the mix of crops in their portfolios of crops. In contrast, the NF analyser farmers achieved this goal by introducing new traditional crops with low gross margin. The other class that was subdivided into subclasses is Class 2 (i.e. PRS farmers). Specifically, this class was subdivided in Subclass 2.1 (i.e. PRS defender farmers) and Subclass 2.2 (i.e. PRS analysers). The first subclass included farmers who achieved the goals of increasing expected gross margin and decreasing business risk of their portfolios by changing the mix of crops. In contrast, Subclass 2.2 included farmers who achieved this goal by introducing new crops into their portfolios.

The objective of the present section is to identify non-economic factors that could explain the different strategies adopted by farmers who belong to the same class but in different subclasses. For this purpose, the same Student $t$ test criterion applied in the last section was adopted.
a) A comparison of Subclasses 1.1 and 1.2 of Class 1

As explained above, Class 1 included farmers who chose a portfolio of crops achieving the same levels of both gross margin and business risk in response to the technological shock (i.e. the removal of material resource restrictions); therefore, this class included NF farmers. What is interesting about these farmers is that some of them were able to maintain the levels of gross margin and business risk by changing the proportion of existing crops in their portfolio of crops. Since these farmers did not innovate by means of the introduction of new activities, they were categorised as defenders (see Table 7.13).

In contrast, the rest of the farmers were able to maintain the levels of gross margin and business risk by means of the introduction of new crops with low levels of gross margin and business risk. Because these individuals developed partial innovation, they were classified as analysers (see Table 7.13). A statistical analysis of these farmers was conducted with the objective of determining whether their different cropping choices were explained by the existence of non-economic drivers. The results are presented in Table 7.22.
Table 7.22 Non-economic drivers explaining strategic behavioural differences between defenders and analysers NF farmers of Class 1.

<table>
<thead>
<tr>
<th>Statement</th>
<th>NF Defenders*</th>
<th>NF Analysers*</th>
<th>t**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have sufficient time for leisure</td>
<td>3.40</td>
<td>4.17</td>
<td>-2.43</td>
</tr>
<tr>
<td>I can further lower the cost of my production</td>
<td>2.40</td>
<td>3.83</td>
<td>-3.10</td>
</tr>
<tr>
<td>Collaborative alliances to increase market power</td>
<td>3.30</td>
<td>4.33</td>
<td>-2.21</td>
</tr>
<tr>
<td>Producing these crops implies collaborative alliances that are difficult to form</td>
<td>4.30</td>
<td>3.00</td>
<td>2.71</td>
</tr>
</tbody>
</table>

*Farmers used the following 5-points Likert scale to indicate the importance that they assigned to non-economic drivers (statements): (1) strongly disagree; (2) disagree; (3) indifferent; (4) agree; and (5) disagree.

**Student t critical value for 30 degrees of freedom at the 5% level of significance: 2.145

This table shows that four non-economic drivers were found to be significant in explaining the different strategies adopted by the NF defender and the NF analyser farmers. To understand why these drivers explained this difference, let us first consider the following antecedent. While both types of farmers achieved the same levels of expected gross margin and business risk in response to the exogenous shock, the NF analyser farmers had a better position on the EPL. This is because they were able to form a portfolio of crops achieving an expected gross margin of £418/ha and a business risk equal to £13,414/ha\(^2\). In contrast, the NF defender farmers were only able to form a portfolio of crops achieving an expected gross margin of £355/ha and a business risk equal to £14,058/ha\(^2\). This situation is shown in Figure 7.18.
This figure shows that the FN defender farmers maximised their expected utility at point $a$ where their indifference curve $E(U(\pi))_{FN-Defender}$ is at $a$ tangent to the efficient frontier $EF_{FN-Defender}$. In contrast, the FN analyser farmers maximised their expected utility at point $b$ where their indifference curve $E(U(\pi))_{FN-Analyser}$ is at $b$ tangent to the efficient frontier $EF_{FN-Analyser}$. What these two subclasses of farmers had in common is that they both were able to maintain their position on the $EPL$ in response to the exogenous shock. That is, the FN defender and the FN analyser farmers maintained their position at points $a$ and $b$, respectively, in response to the exogenous shock. However, they differed in that the latter were located in a better position on the $EPL$ because they were able to form a portfolio achieving a larger level of expected gross margin and a lower level of business risk.

The ability of the NF analyser to reach a better position on the $EPL$ can be explained by the non-economic drivers identified in Table 7.22. According to this table, these individuals considered the formation of collaborative alliances as an important business strategy to increase market power. In addition, they considered that the formation of...
alliances was not difficult. This suggests that these individuals were involved in some sort of cooperation that allowed them to increase negotiation power and to overcome to some extent the existing power imbalance in the relationship between producers and retailers. This, in turn, allowed the NF analyser to form portfolio of crops achieving higher levels of expected gross margin as a consequence of the advantage that they obtained from collaboration. These farmers were also able to reduce the cost of their production which can also explain why they obtained a higher level of expected gross margin with respect to the NF defender farmers. Finally, the NF analyser farmers had the goal of having sufficient time for leisure. It is possible that the formation of collaborative alliances also allowed them to achieve this goal because these alliances normally involve sharing administrative and productive tasks.

In this context, the strategy of introducing new traditional crops in the hypothetical condition in which material resource barriers do not exist (i.e. after the removal of these barriers) probably reflected the capacity of the NF analyser farmers to diversify in the market of traditional crops as a consequence of having more negotiation power and control over their productive costs. This suggests therefore that what prevented these farmers from diversifying in reality is the existence of material resource barriers. In contrast, the strategy of the NF defender farmers of changing the mix of existing crops in their portfolios could reflect a specialisation strategy adopted to gain efficiency given their difficulty in forming alliances and to reduce productive costs. That is, the removal of material resource barriers would help these individuals to change the mix of crops but not to diversify as a consequence of lack of capacity to form alliances.
b) A comparison of Subclasses 2.1 and 2.2 of Class 2

Class 2 included farmers who chose a portfolio of crops achieving higher levels of gross margin and lower levels of business risk in response to the exogenous shock; therefore, this class included PRS farmers. As explained above, two subclasses of farmers were identified in this class. One of them corresponds to farmers who achieved a higher level of expected gross margin and a lower level of business risk by changing the mix of existing crops in their portfolios. Because these individuals did not introduce any type of innovation in this strategy, they were classified as defenders (i.e. PRS defender farmers). The other subclass included farmers who were able to achieve a higher level of expected gross margin and a lower level of business risk by introducing a new crop (potatoes) into their portfolios. Because this strategy involved a partial innovation, these farmers were classified as analysers (i.e. PRS analyser farmers). The levels of expected gross margin and business risk achieved by these subclasses of farmers before and after the shock are presented in Table 7.23.

Table 7.23 Expected gross margin and business risk achieved by the PRS defender and analyser farmers before and after the shock.

<table>
<thead>
<tr>
<th>Variable</th>
<th>PRS Defender</th>
<th>PRS Analyser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected gross margin before the shock (£/ha)</td>
<td>489</td>
<td>416</td>
</tr>
<tr>
<td>Expected gross margin after the shock (£/ha)</td>
<td>622</td>
<td>619</td>
</tr>
<tr>
<td>Business risk before the shock (square £/ha)</td>
<td>11,027</td>
<td>13,512</td>
</tr>
<tr>
<td>Business risk after the shock (square £/ha)</td>
<td>8,670</td>
<td>8,018</td>
</tr>
</tbody>
</table>
According to this table, the PRS defender farmers achieved a better position on the \textit{EPL} than the PRS analyser farmers before the introduction of the shock. However, both subclasses of farmers achieved a relatively similar position on this line after the shock. This situation is shown in Figure 7.19.

![Figure 7.19 Relative positions of PRS analyser and PRS defender farmers on the \textit{EPL} before and after the shock](image)

In this figure, the positions of the PRS analyser and defender farmers on the \textit{EPL} are represented by red and blue circles, respectively. As shown in this figure, the PRS analyser farmers were located on average at point \textit{a} and the PRS defender farmers at point \textit{c}. Because point \textit{c} involved a portfolio of crops achieving a higher level of expected gross margin than point \textit{a}, it is concluded that before the shock the PRS defender farmers achieved a better position on the \textit{EPL} than the PRS analyser farmers. However, after the shock both classes of farmers moved upward along this line reaching
points \( b \) and \( d \). Because these points are located very closed each other, it is concluded that both classes of farmers achieved the same position on the \( EPL \) after the shock.

The implications of this change can be understood from the following analysis. The PRS defender farmers achieved a better position on the \( EPL \) because they produced a portfolio of crops that included traditional crops and potatoes. However, the PRS analyser farmers only included traditional crops in their portfolios and not potatoes. Because potatoes have a much higher level of gross margin than traditional crops, this explains why the PRS defenders achieved a better position. However, the removal of material resource restrictions allowed the analyser farmers to include potatoes in their portfolios. As a result, both classes of farmers were able to choose similar portfolios of crops that included potatoes and this explains why they reached a similar point on the \( EPL \) after the shock. This finding suggests, therefore, that the PRS analysers were facing some particular material resource restrictions that prevented them from producing potatoes. This could be land quality. However, non-economic drivers seemed not to play a role in explaining the different strategies chosen by these two subclasses of farmers. This can be inferred from the following table.

Table 7.24 Differences of non-economic drivers between PRS defender and PRS analyser farmers of Class 2.

<table>
<thead>
<tr>
<th>Statement</th>
<th>PRS Defenders*</th>
<th>PRS Analysers*</th>
<th>( t^{**} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>In decision making I take the environment into consideration, even when if it lowers gross margin</td>
<td>3.00</td>
<td>4.27</td>
<td>-2.77</td>
</tr>
</tbody>
</table>

*Farmers used the following 5-points Likert scale to indicate the importance that they assigned to non-economic drivers (statements): (1) strongly disagree; (2) disagree; (3) indifferent; (4) agree; and (5) disagree.

**Student \( t \) critical value for 30 degrees of freedom at the 5% level of significance: 2.145
This table shows that the only non-economic driver that was found to be statistically significant in explaining behavioural differences between the PRS defender and analyser farmers was their attitudes towards including environmental considerations in their decision making. However, because both types of farmers chose similar crop allocations in response to the shock, this non-economic driver was not considered a relevant variable explaining the different strategic choice made by these individuals.

7.3 Managerial and Policy Implications of the Results

The results obtained in the present chapter have important managerial and policy implications. They are discussed as follows.

7.3.1 Managerial Implications of the Results

From a managerial point of view, most of the ESBF were limited in terms of their capacity to increase and even sustain competitive advantage in response to the closure of the ASBF. According to the analysis on dynamic capabilities developed in Chapter Six, this is because these individuals faced a number of barriers that prevented them from adopting crops with high levels of gross margin. The most important barriers identified in this study were lack of material resources such as capital. This is because the adoption of crops with high levels of gross margin requires the use of expensive and specific machinery and also land quality that is not always available. Even though these farmers had core competences in the production of traditional crops because they had technical and market experience related to these crops they still faced material barriers. This explains why these individuals adjusted to the closure of the ASBF by adopting traditional crops with low gross margin to replace sugar beet after the implementation of
the SRR. That is, they adopted a defender strategy in terms of the Miles and Snow’s typology. This decision could also have been influenced by the fact that the prices of some traditional crops were very high in year 2008. This is formally shown in Table 7.25. In order to facilitate the recognition of the changes of these prices, they were transformed into Index Prices and plotted in Figure 7.20.

Table 7.25: Prices for selected crops paid to producer.

<table>
<thead>
<tr>
<th>Year</th>
<th>Barley (£/tonne)</th>
<th>Wheat (£/tonne)</th>
<th>Oilseed Rape (£/tonne)</th>
<th>Oats (£/tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>65</td>
<td>73</td>
<td>131</td>
<td>67</td>
</tr>
<tr>
<td>2006</td>
<td>74</td>
<td>81</td>
<td>154</td>
<td>76</td>
</tr>
<tr>
<td>2007</td>
<td>116</td>
<td>129</td>
<td>189</td>
<td>108</td>
</tr>
<tr>
<td>2008</td>
<td>125</td>
<td>152</td>
<td>305</td>
<td>103</td>
</tr>
<tr>
<td>2009</td>
<td>92</td>
<td>109</td>
<td>238</td>
<td>92</td>
</tr>
<tr>
<td>2010</td>
<td>100</td>
<td>127</td>
<td>260</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Food and Agricultural Organization (2011) and Department for Environment Food and Rural Affairs (2011a)

Figure 7.20: Index Price for selected crops (Base: 2005 = 100)

Developed by the Author based on the information presented in Table 7.25.
This figure shows that the prices of oilseed rape, barley and wheat reached a pick in 2008. As shown in this figure, the highest increment was verified in the price of oilseed rape which corresponds to the most relevant crop used by the farmers in the sample to replace sugar beet after the closure of the ASBF. This suggests the possibility that some farmers anticipated the price increment of some traditional crops such as those presented in Figure 7.20 and, as a consequence, they planned to grow them.

The main question arising from the observations made in this section is the consideration of how farmers could eventually improve their capacity to increase competitive advantage. Because lack of material resource restrictions were identified as the most important barriers preventing these individuals from adopting crops with high levels of gross margin, this suggests that this capacity could be improved by removing these barriers. The results obtained in the present chapter revealed, however, that removing these barriers did not necessarily help these farmers to achieve a better competitive position in the market. This is because there were a number of non-economic drivers that affected their cropping decisions in different ways.

This suggests that any business strategy adopted to increase competitiveness and that is based on the removal of material resource restrictions has to be accompanied with other auxiliary specific strategies. The types of auxiliary strategies will depend on the type of farmer that is considered. For example, it was found that the NF farmers (i.e. farmers who chose portfolio of crops achieving the same levels of expected gross margin and business risk in response to exogenous shocks) did not take advantage of the removal of material resource restrictions. This was because their productive capacity was limited. As a consequence, they were unable to meet the demand requirements of retailers for crops with high gross margin. This suggests that these farmers would have benefited
from the removal of material resource restrictions by adopting auxiliary strategies such as the formation of collaborative alliances to increase negotiation power and to increase their productive capacity.

On the other hand, the RRE farmers (i.e. farmers who chose a portfolio of crops achieving a lower level of expected gross margin and a larger level of business risk in response to exogenous shocks) did not take advantage of the removal of material resource restrictions because these individuals were apparently lacking in experience. This suggests that a suitable auxiliary strategy for these farmers would be to enrol on some sort of formal training in order to improve their managerial and technical capabilities.

Finally, the PRE farmers (i.e. farmers who chose a portfolio of crops achieving higher levels of expected gross margin and business risk in response to exogenous shocks) were the farmers who most benefited from the removal of material resource restrictions. This is because they were the only individuals who adopted crops with high levels of gross margin in response to the removal of these restrictions. The reasons for this result are associated with their attitudes towards farming, namely that these individuals were more satisfied and motivated at work than both the NF and the PRS farmers, and identified more strongly with the farming community. The PRE farmers also put a highly value on hard work. Given that the production of crops with high gross margin is very time demanding, this explains why these individuals were more willing to adopt these crops. Finally, these individuals were more willing to undertake riskier activities. This finding suggests that motivation, satisfaction, farming community involvement, attitudes towards risk, and willingness to work hard play a crucial role in determining the degree of success of farmers.
7.3.2 Policy Implications of the Results

The results obtained in this chapter have an important policy implication. This is that the incorporation of programmes of local development involving the removal of material resource restrictions (e.g. removal of capital constraints; introduction of irrigation systems, etc) would not necessarily deliver the expected benefits in the rural sector. This is because the results revealed that farmers respond heterogeneously and sometimes in a suboptimal way in response to the removal of these restrictions. This suggests, again, that any programme of local development involving the removal of some material resource restrictions should be accompanied with auxiliary strategies depending on the characteristics of the farmers.

As explained in the last section, the NF would benefit if the removal of these restrictions was accompanied with the formation of collaborative alliances with the objective of increasing the productive capacity of these farmers. However, there is a problem associated with the formation of these alliances that was detected in the current research. This is that a significant number of farmers argued that they were not in general willing to form alliances because they did not trust their potential partners. This suggests that any policy programme has to address the potential problem of distrust and this could be done by introducing additional policy support. For example the creation of a local office that could reduce distrust by formalising legal contracts among partner farmers. This office could assume administrative tasks such as defining property rights and specific tasks among farmers, and also could provide guidance to these individuals in terms of market opportunities. This idea was well received by the farmers in the
sample. Moreover, this office could operate as a private business contributing, in this way, to the development of local rural areas.

Regarding the RRE farmers, these individuals would benefit from the removal of material resource restrictions if this action were accompanied by some sort of formal training that could help them to improve their managerial and technical capabilities. As explained in the last section, this is because these farmers apparently had a lack of experience. As a consequence, a policy package programme of local development involving the removal of material resource restrictions could be accompanied with training activities in order to have a real positive impact on these farmers. Formal training could be provided by local colleges or universities and they could be financed by funds obtained from the policy package.

Finally, the last section explains that motivation, satisfaction, farming community involvement, attitudes towards risk, and willingness to work hard played a crucial role in determining the degree of success of farmers in response to the removal of material resource restrictions. This suggests that any policy programme could have better results in the rural area if they also consider accessory activities that help farmers to be involved with the farming community and to gain more satisfaction from the farming activity. This could be achieved by the development of communal meetings organised by policymakers and with the help of, for example, the NFU.
7.3.3 A Model to Predict Farmers’ Behaviour in Response to the Removal of Material Resource Restrictions

One of the questions that a policymaker could ask in relation to the results obtained in this thesis is how to identify types of farmers according to their possible strategic behaviour in response to a removal of material resource restrictions (e.g. incorporation of capital; better irrigation systems; technology adopted to increase land quality; etc). Being able to answer this question would offer better opportunities to develop realistic and useful policy programmes that could include auxiliary strategies designed to benefit some specific types of farmers. The objective of this section is to offer a behavioural predictive model based on the results that could be used to provide guidance to policymakers in this context. This model is presented in Figure 7.21:
Figure 7.21 Predictive model of farmers’ strategic response to the removal of material resource restrictions.
The way in which this model works is explained as follows. In order to predict the possible strategic behaviour followed by a target group of farmers in response to the removal of material restrictions, one sample of these farmers should be selected. If the valuations assigned on average by these farmers to the statements presented in this model coincided with the valuation given in the brackets, then these individuals should be considered as following the arrow “yes” (see Figure 7.21). In contrast, if their valuations did not coincide on average with the valuation given in brackets, then these farmers should be considered as following the arrow “not”. As an example, suppose that in the status quo condition (i.e. the farming condition before the removal of material resource restrictions) farmers provided on average the following valuations (in brackets) to the following statements:

a) Retailers demand a volume that I cannot produce (indifferent)

b) Enjoy my work (agree)

c) Provide for next generations (disagree)

d) Age (53 years old in average)

e) Belonging to the farming community (agree)

f) Farming is still fun and satisfying (indifferent)

g) Legislation spoils the pleasure in my work (agree)

h) I am not familiar with the productive process of crops with high gross margin (agree)

Since most of these valuations coincide with the valuations given in the model, these farmers should be assumed to follow the arrow “yes”. This arrow leads to a second set of statements. Suppose that the farmers in the sample provided on average the following valuations (in brackets) to this set of statements:
a) Have sufficient time for leisure (strongly agree)
b) I can further lower the cost of my production (agree)
c) Collaborative alliances to increase market power (important)
d) Producing these crops implies collaborative alliances that are difficult to form (disagree)

Because in this hypothetical case most of the valuations provided by the farmers did not coincide with the valuations given in the model, these individuals should be assumed to follow the arrow “not”. This arrow finally leads to a classification that corresponds to NF farmers (i.e. farmers who form portfolios of crops achieving the same levels of business risk and gross margin in response to an exogenous improvement) and analysers (i.e. they partially innovate by introducing new crops with low gross margin in response to an exogenous shock).

Having identified that the farmers in the sample were NF analysers, it is easier for policy makers to design a policy program suitable for these individuals. To understand this, note that it is already known that these individuals were prevented from achieving a better position in the market because they faced productive capacity limitations. However, it is not difficult for these individuals to form collaborative alliances which, according to the results obtained in Section 7.2.3, is what differentiated these farmers from the NF defenders. As a consequence, a good policy of local development for these individuals would include the removal of material resource restrictions coupled with a strategy aimed at increasing collaboration with the purpose of increasing their productive capacity. This would ensure that these farmers would be able to fill retailers’ demand for crops with high levels of gross margin.
7.4 Conclusions

The objective of the chapter was to show the results obtained in the dynamic stage of the research. That is, in the stage that studied the hypothetical behavioural responses of the ESBF to the removal of material resource restrictions (i.e. the introduction of an exogenous shock). In order to develop this analysis, these farmers were asked to report the crop allocations that they would choose if they did not face these restrictions. The results revealed that farmers responded heterogeneously to the removal of material resource barriers suggesting that only a fraction of these individuals cared about reaching a better competitive position in response to this exogenous shock. It was concluded, therefore, that a number of non-economic drivers influenced the strategic behaviour of the farmers included in the sample.

According to the Income-Risk Matrix typology that was proposed in this thesis, two classes of farmers who adjusted by reaching a better position were identified: progressive risk enlarger farmers PRE: and progressive risk saver farmers PRS.

The main characteristic of the PRE farmers is that these individuals adjusted by introducing crops with very high levels of gross margin in their portfolios in response to the shock revealing that what prevented these individuals from adopting these crops was the existence of material resources barriers. These farmers were the most successful farmers in terms of benefiting from the removal of material resource restrictions. According to the results, the strategic choice made by these individuals is explained by three main factors. Firstly, they had positive attitudes towards farming which was reflected in terms of satisfaction at work, high value to hard work, and identification with the farming community. Secondly, they were also more motivated and more
willing to take risk than the rest of the farmers included in the experiment. Finally, they were more familiar with the productive process of crops with high levels of gross margin.

The PRS were able to reach a better competitive position by specialising in the production of traditional crops to gain efficiency. The results revealed that these farmers adopted this strategy because they were not interested in adopting crops with high levels of gross margin. This finding suggests that the PRS were less willing to take risk in order to reach a better competitive position than the PRE farmers.

On the other hand, the farmers who did not reach a better competitive position in response to the shock were classified as neutral farmers NF; regressive risk saver farmers RRS; and regressive risk enlarger farmers RRE.

The main characteristic of the NF is that these farmers maintained the same competitive position because they chose a portfolio of crops achieving the same levels of expected gross margin and business risk in response to the removal of material resource barriers. The results revealed that these individual adopted this strategy because they faced productive capacity constraints. As a consequence, they were unable to fill retailers’ demand for crops with high gross margin. In this context, the best option for these farmers was to change the mix of crops in their portfolios in order to maintain their position in the market of traditional crops.

Only one farmer was classified as a RRS and the main characteristic of this individual is that he adjusted to the shock by choosing a portfolio of crops achieving lower levels of expected gross margin and business risk. This farmer was a reactor under the Miles and
Snow’s typology because this individual, despite being successful before the removal of material resource restrictions, adopted a completely irrational choice in response to this shock. That is, this farmer decided to give up developing the best activities with the highest levels of gross margin in the beneficial business environment that arose from the removal of material resource restrictions. Apparently, the choice made by this farmer reflected dissatisfaction at work.

Finally, the main characteristic of the RRE is that these farmers adjusted to the shock by choosing a portfolio of crops achieving a lower level of expected gross margin and a higher level of business risk. These farmers apparently made this choice as a consequence of lack of experience.

The results obtained in this chapter have important managerial and policy implications. From a managerial point of view, farmers can take advantage of the removal of material resource restrictions (e.g. introducing capital, better irrigation systems, technologies that improve land quality, etc.) by simultaneously adopting auxiliary strategies. The reason is because the removal of these barriers does not guarantee that farmers will adjust by reaching a better competitive position. For example, NF farmers are prevented from reaching a better position because they also face productive capacity constraints. As a consequence, these individuals could only be benefited from the removal of material resource barriers by adopting simultaneously a strategy that allow them to increase this capacity (e.g. by means of collaborative alliances).

From a policy point of view, on the other hand, policy programmes of local development involving the removal of these restrictions could not necessarily deliver the expected beneficial outcomes. This is because farmers might behave
heterogeneously and sometimes in a suboptimal way in response to these programmes. This suggests that programmes of local development should also be accompanied with auxiliary strategies to deliver real beneficial results. Recognising types of farmers, therefore, plays a crucial role for policymakers. This chapter closes by proposing a behavioural model that can be used to predict farmers’ behaviour and to recognise types of farmers in terms of their responses to a removal of material resource restrictions. This model could constitute useful guidance to policymakers in the recognition of types of farmers, which could then inform the design of reliable programmes of local development.

Finally, as discussed in Section 5.3.3 and in the conclusions of Chapter Six, it is important to emphasise that the results obtained in this chapter could be biased to some extent as a result of the snow ball technique adopted in this research. That is, in this technique farmers suggest friends meaning that individuals in the sample could be like minded. As a consequence, the results could reflect the behaviour of a liked minded fraction of ESBF rather than the behaviour of the population. This is why the results have to be considered with caution.
Chapter Eight: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS
FOR FUTURE WORK

8.1 Introduction

The focus of this research has been on farmers’ strategic behaviour in dynamic business environments. In particular, the objective was to gain an understanding of the way in which the ex-sugar beet growers in the West Midlands region (ESBF) adjusted in response to the incorporation of the Sugar Regime reform (SRR) in 2006. An important consequence of this reform was the closure of the sugar beet factory located at Allscott in Shropshire (ASBF). This closure negatively affected the business of the ESBF because these individuals were unable to sell their production of sugar beet in alternative factories as they were located far away from their productive area. In addition, the ESBF faced a higher level of business risk after the reform because sugar beet was a virtually risk-free as the farmers used to receive a guaranteed price before they committed to the production of this crop (business risk is formally defined in Footnote 1 in Chapter One).

The present research has attempted to address the issue of why the ESBF adjusted to the closure of the ASBF by apparently replacing sugar beet with traditional crops with low levels of gross margin such as oilseed rape, wheat and barley as suggested by Clothier (2010) and Department for Environment Food and Rural Affairs (2010a). As outlined, this choice was puzzling because there were other alternatives with higher levels of gross margin that could have been used to replace sugar beet such as carrots and parsnips among others. This choice suggested that these individuals were not gross margin maximisers. The fact that the ESBF did not behave as gross margin maximisers
raised a number of research questions that were considered in the present research: Why did sugar beet growers choose crops with relatively low gross margin at variance with the expectations of economic theory? How did farmers make these decisions? Which variables/factors influenced farmers in making these decisions? And how did farmers reconfigure their business strategies?

It was not easy to answer these questions with the information available in the public domain and from existing frameworks used to predict farmers’ cropping decisions. This is because these frameworks normally assume the existence of a representative farmer who seeks to maximise gross margin (although not all models adopt this assumption). However, the cropping choice made by the ESBF suggested that farmers’ cropping decisions were influenced by a number of factors that are not considered by traditional frameworks. It was found that a holistic model of this nature, able to capture different aspects of farmers’ strategic cropping decisions, has not been developed so far. This constitutes the main academic gap identified in this investigation.

The main objective of this thesis was to propose a multivariate model to study the influence of economic and non-economic factors on farmers’ strategic cropping decisions. That is, the aim of this thesis was to produce an alternative modelling framework that is able to identify economic and non-economic considerations that are involved in farmers’ strategic behaviour. In order to achieve this objective, a literature review was conducted with the purpose of identifying complementary alternative approaches that could be used to explain the cropping choice made by the ESBF. While several of these approaches overlap to some degree, they were useful to identify a number of economic and non-economic (i.e. social-psychological variables) drives that
were considered in the proposed multivariate model. These drivers were considered as potential factors explaining farmers’ cropping decisions.

The proposed multivariate model was used in this thesis to gain an understanding of the way in which the ex-sugar beet growers in the West Midlands region (ESBF) adjusted in response to the closure of the ASBF. This analysis was called the static stage of the research. The framework was also used to determine how farmers would behave if material resource restrictions affecting their cropping choices were removed (i.e. if policy programmes of local development were introduced). This extension was called the dynamic stage of the research.

This chapter is structured as follows. Section 8.2 explains how the main objective of the thesis was achieved. That is, it describes the main approaches identified in the literature review that were considered in the proposed multivariate model. Section 8.3 discusses the results obtained in the static stage of the research. Section 8.4 discusses the results obtained in the dynamic stage of the research. Section 8.5 describes the practical implications and recommendations from the research. Finally, Section 8.6 discusses weakness and strengths of the investigation, and provides recommendations for future research.

8.2 Research Development to Achieve the main Objective of the Research

The main objective of this thesis was to develop a multivariate model able to capture economic and non-economic drivers in explaining farmers’ cropping decisions. For this purpose, a literature review on different approaches that could explain the low gross margin choice made by the ESBF was conducted.
8.2.1 Approaches Used in the Proposed Multivariate Model

One of the approaches considered in the literature review is related to the capacity of farmers to develop dynamic capabilities. From this point of view, it is possible that the ESBF adopted mainly oilseed rape and oats to replace sugar beet because they faced restrictions preventing them from creating competitive advantages in the market of crops with high levels of gross margin. Another approach that was considered that could explain the choice made by the ESBF is the utilitarian approach. According to this point of view, risk averse farmers deviate from gross margin maximisation when they take into account business risk. The third approach reviewed is the multiple goals approach. According to this approach, farmers deviate from gross margin maximisation when they consider non-economic goals such as maintaining family tradition when making their cropping decisions. The fourth approach identified in the literature review corresponded to the theory of planned behaviour. According to this theory, there are a number of psychological factors that could influence farmers’ strategic behaviour. These factors can be classified in three groups: (i) attitudes towards different aspects of the farm (e.g. positive attitude towards adopting new alternatives in the farm); (ii) subjective norms (e.g. how important is the opinion of neighbours for a farmer when making cropping decisions); and (iii) subjective behavioural control (e.g. farmer’s believe that he/she has control over the production of crops with high gross margin). Another approach considered in the literature review was the market and material resources barriers approach. According to this approach, farmers could have adopted crops with low gross margin to replace sugar beet because they faced different market and material resource barriers that prevented them from producing crops with higher levels of gross margin. Finally, the last approach considered in the literature review was the institutional theory
which was useful to explain a possible collective behaviour of the ESBF in term of the options adopted by these farmers in response to the closure of the ASBF. It is important to clarify that all these approaches overlaps to some degree. Nonetheless, they all assisted in the identification of a number of economic and non-economic drivers that could potentially explain the cropping choice made by the ESBF.

8.2.2 Contributions Associated with the Proposed Multivariate Model

The main contribution of the proposed model is that it offers an alternative conceptualisation of farmers’ cropping decision making that not only includes economic variables as most traditional frameworks do, but also non-economic considerations. In addition, the model offers the possibility to identify theoretically heterogeneous behavioural patterns across farmers that can be tested empirically. In contrast, some models cannot capture heterogeneous behaviour across farmers because these frameworks rely on the assumption of the existence of a representative farmer. Eight theoretical behavioural patterns were inferred from the proposed model and they were formalised as eight testable hypotheses. Six of these hypotheses were considered in the static stage of the research. The two remaining hypotheses, in contrast, were considered in the dynamic stage of the research.

8.3 The Static Stage of the Research

The aim of the static stage of the research was to gain an understanding of the way in which the ex-sugar beet growers in the West Midlands region (ESBF) adjusted in response to the closure of the ASBF. For this purpose, the multivariate holistic model developed in this thesis was applied to a sample of ESBF in order to identify the main
economic and non-economic drivers in explaining the decision making process of these farmers. This analysis was called the static stage of the research because it considered a single year (year 2008) to study how farmers adjusted to the closure of the ASBF. This year was used because it was assumed that the shock caused by the SRR in 2006 was by this stage internalised by these farmers.

Six theoretical behavioural patterns were inferred from the proposed model and they were formalised as six testable hypotheses. These hypotheses were established in the context of the static stage of the research which was designed to provide a possible explanation for the choices made by the ESBF in response to the closure of the ASBF. This analysis adopted two general assumptions that seemed to explain this choice.

The first assumption was that these farmers were all risk averse. This assumption could explain why these individuals replaced sugar beet with crops with low gross margin. This idea was formalised in a hypothesis referred to as the hypothesis of risk aversion (HRA). The second assumption was that the ESBF had the same coefficient of absolute risk aversion or equivalently the same attitudes towards risk (this coefficient is formally defined in Section 3.3.2.1 and Appendix D). This could explain why most of these individuals chose traditional crops with similar levels of expected gross margin and business risk to replace sugar beet. This idea was formalised as a hypothesis referred to as the hypothesis of similar coefficient of absolute risk aversion (HSCRA). Using these assumptions, an optimal path was inferred that corresponded to a negative relationship between the expected gross margin and business risk of the portfolio of crops chosen by farmers facing different restrictions such as land quality.
The novel economic theory sustaining this analysis was named in this thesis as the multiple efficient frontiers theory (MEFT) and the optimal path identified from this theory was called the efficient portfolio line\(^6\) (EPL). According to the MEFT, two points on this line represent two risk averse farmers having the same attitudes towards risk but facing different restrictions. In terms of the proposed multivariate model, this line is consistent with the utilitarian approach and the market and material resource barriers approach. This is because risk aversion behaviour is associated with the utilitarian approach, and restrictions explaining different positions on the EPL are associated with the market and material resource barriers approach (a formal mathematical derivation of this relationship is presented in Appendix H). The existence of this relationship was formalised as a hypothesis referred to as the hypothesis of optimum path (HOP). According to the analysis developed in the static stage of the research, deviations around the EPL would be explained by factors associated with some approaches considered by the proposed multivariate model: farmers’ differences in their ability to develop dynamic capabilities; the multiple goals approach; and the theory of planned behaviour. These possible theoretical deviations were formalised in three additional hypotheses: (i) the hypothesis of non-economic drivers (HNE) establishing that farmers’ cropping decisions are influenced by non-economic drivers (i.e. socio-psychological variables); (ii) the hypothesis of determinants of dynamic capabilities (DC) associated with individual characteristics (HIC) establishing that among the determinants of DC associated with individual characteristics, only differences of self-motivation and attitudes towards risk generate deviations around the EPL; and (iii) the hypothesis of determinants of dynamic capabilities associated with Social Interaction (HSI). This establishes that when farmers face market and material resources barriers preventing them from producing crops with high levels of gross

\(^6\) A formal discussion of how this line is generated is presented in Section 4.3.1 and in particular in Subsection 4.3.1.3. A more elaborated derivation of this line in mathematical terms if presented in Appendix D.
margin, social interaction (i.e. participation in collaborative alliances and social networks) can only generate deviations around the EPL when it helps farmers either to gain negotiation power of productive efficiency.

In order to gain a better understanding of the way in which the ESBF adjusted to the closure of the ASBF, the static stage of the research was subdivided in three phases. Phase I provided some geographical and social descriptions of the farmers in the sample. Phase II analysed the capacity of the ESBF to develop dynamic capabilities. Finally, Phase III studied the allocation of crops chosen by these farmers in 2008 with the objective of testing the six of the hypotheses described above. The results obtained in these phases are described as follows.

8.3.1 Results of Phase I of the Static Stage of the Research

The objective of Phase I was to identify variables associated with farmers’ individual characteristics such as age and educational training, and differences associated with their farms such as farm size, among others. The purpose was to use these variables as possible explanatory variables in the regression analyses developed in Phase III of the static stage of the research.

The sample used in the research comprised 48 ESBF who were on average 52 years old. The oldest was 71 and the youngest 22 years old. Only one woman was included in the sample. 70.8% of the farmers received educational and agricultural training in either colleges or related institutions, 12.5% gained a Bachelor in agricultural sciences, and 16.7% did not receive formal training. Regarding farm ownership, 14.6% of the farmers in the sample were the owners of the farms where they worked, 14.6% were tenants,
54.1% were the owners of a fraction of the farm, and 16.7% did not provide this information. Finally, the average of the farm size in terms of the total area in hectares was 377 (SD = 304.7) and the number of individuals working on the farm was on average 2.4 on average (SD = 2.06).

The results obtained in this Phase also supported the suggestion made by Clothier (2010) and Department for Environment Food and Rural Affairs (2010a) that the ex-sugar beet growers replaced sugar beet with crops with low gross margin in response to the closure of the ASBF. The most relevant were oilseed rape and oats.

8.3.2 Results of Phase II of the Static Stage of the Research

The objective of Phase II was to determine whether the ESBF had the ability to develop dynamic capabilities (i.e. the ability to integrate, reconfigure, gain and release resources in response to environmental changes in order to reach and sustain competitive advantage) after the closure of the ASBF. For this purpose, a model of dynamic capability based on the literature review was proposed. This model considered 15 drivers that have been argued to help firms to develop the main components of dynamic capabilities: (i) adaptive capability (i.e. firm’s ability to identify and capitalise on emerging market opportunities); (ii) absorptive capability (i.e. the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends in order to innovate); and (iii) innovative capability (i.e. the ability to develop new products and/or markets, though aligning strategic innovative orientation with innovative behaviours and processes). The analysis developed in this phase studied which of these drivers were available for the ESBF.
The results revealed that only few determinants of dynamic capabilities were available for these farmers. They were self-motivation, communication, participation in social networks, and technical and market expertise in relation to traditional crops. Regarding self-motivation, this driver contributes to the development of absorptive capability. The results showed that some farmers recognised the value of crops with high levels of gross margin. Moreover, these individuals argued that they could easily learn how to produce these crops because they had the capacity to assimilate this information. However, they did not adopt these alternatives because they placed more value on having free time. This finding suggests that self-motivation depended on farmers’ goals but not on exogenous factors such as market conditions. As a consequence, the ESBF had full control on self-motivation and this is why this driver was considered as available for these individuals.

Communication, on the other hand, helps firms to develop both absorptive capability and innovative capability. This is because good communication among members helps the diffusion of new information that can be used for commercial ends. Because the number of individuals operating in the farm was generally found to be small (2.4 on average), it was inferred that lack communication among members of the farm was not an issue as in the case of large companies. Participation in social networks also helps firms to develop absorptive and innovative capabilities. This is because links constitute informational channels for new information that could be used for commercial ends and innovation. The results revealed that a significant proportion of farmers in the sample participated in networks in either the free or the contract market. This indicates that participation in social networks was a common practice for the ESBF. Finally, technical and market experience helps firms to develop innovative capability in the form of incremental production innovation (i.e. to improve the performance of existing
products). This is because this experience strengthens core competences, reduces production costs and reduces innovation time. The results revealed that the ESBF had technical and market experience associated with the production of traditional crops.

The results obtained in Phase II suggest that, from the point of view of the dynamic capability approach, the low gross margin choice made by the ESBF to replace sugar beet could be explained by two factors. The first factor is that important drivers of dynamic capabilities that could have helped these individual to create competitive advantage in the market crops with high gross margin were not available for these farmers. For example, these individuals faced capital constraints that prevented them from acquiring the expensive machinery that is needed to produce these crops. The second factor is that the few available drivers of dynamic capabilities apparently favoured the strategy of maintaining their competitive position in the market of traditional crops. As a consequence, the optimal strategy of the ESBF to adjust to the closure of the ASBF was to adopt a defender strategy consistent with their experience and core competences.

In summary, the results found in this phase revealed that the ESBF were business with high levels of inertia, and this reflects the fact that these individuals had few available drivers of dynamic capabilities when the ASBF was closed. This explains why these farmers adopted a defender strategy.

8.3.3 Results of Phase III of the Static Stage of the Research
As explained in the last section, it appeared that the ESBF chose a defender strategy to adjust to the closure of the ASBF because they had core competences in the market of traditional crops. That is, they were able to maintain their current competitive position in the market of these crops. One of the factors explaining this fact is that these individuals faced important restrictions that prevented them from adopting crops with high levels of gross margin. This, however, does not mean that these individuals were passive in adopting the defender strategy. On the contrary, as inferred from the MEFT proposed in this thesis, it was expected to find an optimal negative relationship between the levels of expected gross margin and business risk (i.e. the efficient portfolio line (EPL) described in the introduction of the present chapter). It was also expected to find deviations around this line that were caused by non-economic drivers and different capacities to develop dynamic capabilities. The objective of Phase III of the static stage of the research was to investigate these predictions by using the proposed multivariate model. For this purpose, a number of hypotheses related to these predictions were tested. The results are discussed as follows.

8.3.3.1 Testing the HRA and the HSC

The first analysis conducted in this phase was focused on farmers’ attitudes towards risk. The idea was to determine the validity of two main assumptions that seemed to explain the cropping choice made by the ESBF to some extent. The first assumption is that the ESBF were risk averse and this assumption was based on the observation that these farmers chose crops with low gross margin to replace sugar beet. This is because low gross margin is associated with low levels of business risk. This idea was formalised in a hypothesis called the hypothesis of risk aversion (HRA). The second
assumption was that the ESBF had the same coefficient of absolute risk aversion. This is because most of these individuals chose traditional crops with relatively low levels of gross margin and business risk to replace sugar beet. This idea was formalised in a hypothesis called the hypothesis of similar coefficient of absolute risk aversion (HSC).

An econometric analysis that used data collected from an experimental method applied to the farmers in the sample strongly supported these two hypotheses. That is, it was found that the ESBF were indeed risk averse and that they had the same coefficients of absolute risk aversion. There are two main implications of this result. Firstly, differences in crop allocations across the ESBF cannot be explained by differences in their attitudes toward risk. This implication is important because a related piece of research has argued that differences of crop allocations are only explained by differences in attitudes towards risk aversion, and these attitudes can be influenced by social-geographical factors (see, for example, Feinerman and Finkelshtain, 1996; Dillon and Scandizzo, 1978; and Halter and Beringer, 1960). The results obtained in this thesis suggest, conversely, that there are other factors explaining these differences in crop allocations that have not been identified so far. Identifying these factors was one of the main contributions of this thesis. The second implication is that the MEFT could be tested using the sample considered in the current research because the theoretical EPL inferred from this theoretical development can only arise when the HRA and the HSC both hold (see Section 4.3.1 and Appendix H). This analysis is presented in the following section.

8.3.3.2 Testing the HOP
As explained above, the MEFT proposed in this thesis predicted the existence of a negative relationship (i.e. the EPL) that arises when risk averse farmers having the same coefficient of absolute risk aversion face different market and resource barriers preventing them from producing crops with high levels of gross margin. This idea was formalised in a hypothesis called the hypothesis of optimal path (HOP). An econometric analysis conducted with data collected from the questionnaire and from the public domain strongly supported the existence of this line. This means that even when the ESBF adopted a similar defender strategy to adjust to the closure of the ASBF, they chose portfolios of crops achieving different levels of expected gross margin and business risk. This finding revealed that these farmers cared about maximising gross margin and minimising business risk simultaneously. However, they achieved different levels of expected gross margin and business risk because they faced different constraints such as land quality. In other words, their optimisation process was conditioned by these restrictions. Given the relevance of this result, its implications are formally discussed in Section 8.5.

8.3.3.3 Testing the HNE, HIC and HSI

In order to determine whether non-economic drivers and differences in the capacity to develop dynamic capabilities influenced farmers’ cropping decisions (i.e. whether deviations around the EPL were explained by these factors), three hypotheses were tested using an econometric approach: (i) the hypothesis of non-economic drivers (HNE); (ii) the hypothesis of determinants of dynamic capabilities associated with individual characteristics (HIC); and the hypothesis of determinants of dynamic capabilities associated with Social Interaction (HSI).
The results strongly supported the HNE and the HIS, but the HIC was rejected meaning that individual characteristics associated with self-motivation did not explain deviations around the EPL. Regarding the HNE, it was found that farmers who assigned a higher importance to the goal have independence and freedom from supervision; the attitudes I regularly negotiate with suppliers and buyers; the perceived behavioural control I can further lower my production costs, the material and resource barriers associated with the statement specialisation in order to obtain high production; and the market barriers retailers demand quality that it is difficult to achieve, retailers demand a volume that I cannot produce, and I am not able to innovate to the extent required to enter the market chose portfolios of crops achieving higher levels of expected gross margin per unit of business risk. In contrast, farmers who assigned a higher importance to the goals maintaining the family tradition and provide for next generations; the attitude farming is still fun and satisfying; the perceived behavioural control I'm well informed on the relevant legislation for my farm; and the subjective norm the way other farmers think about my farm is important to me; chose portfolios of crops achieving lower levels of expected gross margin per unit of risk.

Regarding the HIC, on the other hand, it was found that farmers who assigned a higher importance to the statement collaborative alliances to increase negotiation power chose a portfolio of crops with higher expected gross margin per unit of risk. This is because these alliances help farmers either to adopt crops with higher gross margin when removing marker barriers or to obtain better prices for their existing production.

It is interesting to note that none of the social-geographical variables described in Phase I of the static stage of the research were significant in explaining deviations around the
The only geographical variables that were significant were proximity to Wolverhampton and Worcester. The results revealed that farmers who were located near these cities chose portfolios of crops achieving lower levels of expected gross margin per unit of business risk. The reason is because they faced irrigation restrictions. As a consequence, these individuals had to increase the area covered by traditional crops with low levels of gross margin.

8.3.3.4 The Outliers

The results also revealed the existence of three outliers who did not follow the optimal pattern described by the EPL. Two of these outliers were farmers who produced crops with very high levels of gross margin (e.g. carrots, parsnips, strawberries and raspberries, among others). As a consequence, they formed portfolios achieving a high level of expected gross margin. This is why these individuals were considered as successful farmers. One of them was able to produce carrots because he formed a collaborative alliance with another farmer who had free access to a market for this crop. The other successful farmer had a farm shop located near the farm. This shop allowed him to ensure a clientele for his production of crops with high gross margin. The third outlier, on the other hand, allocated a large proportion of the farm land to the largely risk-free activity of renting out land negatively affecting the expected gross margin of the portfolio of crops.

8.3.4 Research questions
The results obtained in the static stage of the research provides clear responses to the research questions established in this thesis (see Section 2.6 in Chapter Two). This is formally discussed as follows.

1. Why did sugar beet growers choose crops with relatively low gross margin at variance with the expectations of economic theory? According to the results, farmers adopted crops with low gross margin because they had few opportunities to develop dynamic capabilities. As a consequence, they adopted a defender strategy in order to take advantage of their core competences in the production of these crops.

2. How did farmers make these cropping decisions? According to the results, these individuals were all risk averse and had the same coefficient of absolute risk aversion (i.e. the HRA and the HSCRA were both verified). This implies that they all cared about maximising expected gross margin and minimising business risk simultaneously. Because these farmers faced different restrictions such as differences in land quality, this optimal behaviour was captured as a predictable path consistent with the Efficient Portfolio Line inferred from the Multiple Efficient Frontiers theory proposed in this thesis (i.e. the HOP was verified).

3. Which variables/factors influenced farmers in making these decisions? The results revealed that farmers’ strategic behaviour was also influenced by a number of factors that caused deviations around the Efficient Portfolio Line: (i) non-economic drivers such as farmers’ goals, farmers’ attitudes towards different aspects of the farm, perceived behavioural control, subjective norms, and the existence of specific market and material resource barriers (i.e. the HNE was verified); (ii) farmers’ participation in
4. How did farmers reconfigure their business strategies? According to the results, the way in which farmers reconfigured their business strategies strongly depended on the restrictions that they were facing when the Sugar Regime reform was implemented. Some of these restrictions were capital constraints; low quality of land; lack of knowledge of crops with high levels of gross margin; and difficulty in getting access to markets of these crops, among others. Because these farmers had core competences in the production of traditional crops, the best alternative for these individuals (given their restrictions) was to replace sugar beet with traditional crops with low levels of gross margin. This allowed them to use existing machinery and to use their existing knowledge in order to maintain their competitive position in the market of traditional crops. On the other hand, it is interesting to notice that the price of some traditional crops adopted by the ESBF to replace sugar beet reached a peak in year 2008 (see Figure 7.20). This suggests the possibility that some farmers anticipated the price increment of these crops and, as a consequence, they planned to grow them. In other words, the increase in the price of these crops probably facilitated the adoption of them by the ESBF.

8.3.5 Contributions of the Static Stage of the Research

There are two main contributions of the development carried out in the static stage of the research. Firstly, it proved to be a useful technique to identify economic and non-economic drivers affecting farmers’ cropping decisions. In contrast, traditional frameworks in general consider only economic drivers explaining farmers’ strategic
behaviour such as gross margin maximisation. Secondly, the proposed model can be used to infer ex-ante behavioural patterns across farmers avoiding the introduction of biases arising when imposing *ad hoc* behavioural assumptions. This is the result of the application of a formal and novel theoretical developments referred to in this thesis as the Multiple Efficient Frontiers Theory.

### 8.4 The Dynamic Stage of the Research

Because it was found that one of the most important constraints limiting the cropping choices of the ESBF was the existence of material resource barriers, it was investigated how farmers would adjust if these barriers were removed as this can be achieved by mean of a policy programme of local development (e.g. incorporation of capital, better irrigation systems, technologies that can be used to improve the quality of land, etc.). It is for this reason that an understanding of the way in which farmers would respond to the removal of these restrictions was considered as an important development of this thesis. This analysis, referred to as the dynamic stage of the research, was conducted by means of an experimental method. In this method, the ESBF were asked to indicate the portfolio of crops that they would choose if material resources restrictions were eliminated.

According to the MEFT proposed in this thesis, two theoretical responses were expected to be found. The first one is that farmers who only faced material resource restrictions but not market barriers preventing them from producing crops with high gross margin would adjust by departing from the *EPL*. That is, these farmers would adopt crops with high levels of gross margin in response to the removal of material resource restrictions.
As a consequence, they would choose a portfolio of crops achieving very high levels of expected gross margin and business risk. This idea was formalised as a hypothesis referred to as the hypothesis of adaptation by departing from the EPL (HAD).

The second theoretical response is that farmers who faced both market and material resource barriers preventing them from adopting crops with high gross margin would adjust by moving upwards along the EPL. To see why, note that farmers who faced these restrictions would be unable to adopt crops with very high levels of gross margin after the removal of material resource restrictions because they still would be facing market barriers. As a consequence, they would only be able to adopt crops with low levels of gross margin. However, they could reach a better position on the EPL because they would be able to choose a portfolio of crops achieving higher expected gross margin per unit of business risk by changing the mix of traditional crops in response to the removal of material resource restrictions. This idea was formalised in a hypothesis referred to as the hypothesis of adaptation along the EPL (HAE). In order to classify the ESBF according to these possible behavioural responses, a novel typology of farmers’ behaviour was proposed. This criterion was called the Income-Risk Matrix typology.

8.4.1 Research Findings of the Dynamic Stage of the Research

The results obtained from an econometric analysis only supported the HAD, but not the HAE on average. Moreover, a number of heterogeneous behavioural responses were found. In order to classify farmers according to these responses, the Income-Risk Matrix criterion proposed in this thesis was adopted. Using this criterion, five behavioural responses to the removal of the material resource restrictions were identified: (i) farmers who chose a portfolio of crops achieving a higher level of expected gross margin and a
lower level of business risk (i.e. progressive risk saver farmers, PRS); (ii) farmers who chose a portfolio achieving higher levels of expected gross margin and business risk (i.e. progressive risk enlarger farmers, PRE); (iii) farmers who chose a portfolio of crops achieving lower levels of expected gross margin and business risk (i.e. regressive risk saver farmers, RRS); (iv) farmers who chose a portfolio achieving a lower level of expected gross margin and a higher level of business risk (i.e. regressive risk enlarger farmers, RRE); and (v) farmers who chose a portfolio of crops achieving the same levels of expected gross margin and business risk (i.e. neutral risk farmers, NR).

The existence of classes of farmers that behaved in a different way from those predicted by the MEFT suggested that non-economic drivers influenced the strategic decisions adopted by these farmers. In order to identify these non-economic drivers, a Student $t$ test criterion was adopted. In particular, this test was used to determine which statements used in the questionnaire were statistically significant in explaining differences across these classes of farmers. The results revealed that the best strategy of the NF was to maintain their position in the market of traditional crops with low gross margin by choosing a portfolio of crops achieving the same levels of expected gross margin and business risk. The reason is because these farmers faced productive capacity constraints that prevented them from filling retailers’ demand for crops with higher levels of gross margin. As a consequence, they were unable to reach a better position along the $EPL$ (i.e. they were unable to choose a portfolio achieving a higher level of expected gross margin and a lower level of business risk). The PRS, on the other hand, were farmers who achieved a better position on the $EPL$ in response to the removal of material resource restrictions. However, they were not interested in adopting crops with very high levels of gross margin to achieve further gains in the market. On the contrary,
they preferred to specialise in the production of traditional crops with the purpose of

gaining efficiency.

The PRE farmers were the most successful farmers in terms of benefiting from the
removal of material resource restrictions. In fact, they were the only individuals who
behaved according to the HAD. According to the results, this is explained by a number
of factors. Firstly, they did not face market constraints preventing them from producing
crops with high levels of gross margin. Secondly, they had a positive attitude towards
some aspects of farming such as satisfaction at work, high value to hard work, and
farming community. Thirdly, they were also more willing to take risks than the rest of
the farmers included in the experiment. Finally, they were more informed with respect
to the productive process of crops with high gross margin.

Only one farmer was classified as a RRS farmer. This farmer adopted a completely
irrational choice in response to the removal of material resource restrictions despite of
being one of the most successful farmers in the sample. His strategy was to give up
developing the best activities with the highest levels of gross margin in the beneficial
business environment that arose from the removal of these restrictions. It is for this
reason that this individual was classified as a reactor under the Miles and Snow’s
typology. Finally, the RRE were farmers who apparently chose a low gross margin
choice as a consequence of lack of experience.

The results also revealed the existence of subclasses of NF and PRS farmers. In
particular, the existence of NF defenders was identified (i.e. NF farmers who changed
the mix of existing crops in their portfolio of crops in response to the exogenous shock);
and (ii) NF analysers (i.e. NF farmers who introduced new crops with low gross margin
in their portfolios in response to the exogenous shock). The NF analysers were able to reach a better position on the EPL than the NF defenders before and after the removal of material resource restrictions because they formed cooperative alliances that allowed them to gain negotiation power. The PRS, on the other hand, were sub-classified PRS defenders and PRS analysers. The only difference between these farmers is that the PRS analysers faced more material resource barriers than the PRS defenders. This explains why the former were unable to produce potatoes before the removal of these restrictions.

8.4.2 Contributions of the Dynamic Stage of the Research

The main contribution of the development carried out in the dynamic stage of the research is the Income-Risk Matrix typology proposed in this thesis. This typology was useful to cluster and classify farmers according to their cropping strategy adopted in response to the removal of material resource barriers. The advantage of this typology is that it considers strategies that are not captured by other typologies found in the literature. The reason is because the latter normally consider firms’ incentives to achieve higher levels of gross margin. In contrast, the Income-Risk Matrix typology also considers farmers’ incentives to minimise business risk. For example, the Miles and Snow’s typology cannot capture the strategy consisting of changing the mix of existing crops in the portfolio as this strategy does not involve either introducing new crops or eliminating existing ones. In fact, this was a common strategy found in this research which was adopted by farmers who were able to change the mix of crops in order to increase the level of expected gross margin and to decrease the level of business risk of their portfolios.
8.5 Implications and Recommendations from the Research

There are three main types of implication of the results obtained in the research developed in this thesis: technical implication; managerial implications; and policy implications. They are described as follows.

The technical implications can be understood when considering the related research into farmers’ behaviour. That is, some related empirical works assume the existence of a representative farmer and this assumption is normally adopted to predict cropping responses to market changes using aggregate data (see for example Gomez-Limon et al., 2003; Lien, 2002; and Hardaker et al., 1997). The result obtained in this thesis puts in doubt the existence of such a representative farmer. This is because even when farmers have the same coefficients toward risk, they face different restrictions that are reflected as different crop allocations along the EPL. Even when removing some of these restrictions, heterogeneous behaviour influenced by non-economic drivers can be found. This means that the results obtained by some of the related research could be biased. This has indeed been detected in the empirical work developed by the Rural Business Unit of the University of Cambridge and the Royal Agricultural College (2004). As explained in the introduction of the present chapter and in Section 2.5 of Chapter Two, this development was based on the assumption that farmers were gross margin maximisers and failed to predict the effects of the SRR on the cropping pattern in the West Midlands. The model proposed in this thesis, in contrast, offers a more realistic description of farmers’ behaviour because it not only consider economic variables, but also non-economic drivers to explain the way in which farmers make strategic cropping decisions.
The managerial implications, on the other hand, are related to the ability of the farmers to sustain or create competitive advantage in response to exogenous shock. One of the most important factors that are needed to develop this capacity is the existence of a sufficient quantity of material resources such as capital. However, the results obtained in the dynamic stage of the research revealed that introducing these resources should be accompanied with auxiliary strategies in order to help these farmers to reach a better competitive position in the market. The specific auxiliary strategies that farmers should adopt in order to be successful will depend on the type of farmer (i.e. NF, PRS, PRE, RRS or RRE). For example, NF farmers would benefit from the introduction of capital by forming collaborative alliances in order to increase their productive capacity. Only if this were the case would individuals be able to meet retailers’ demand for crops with high levels of gross margin.

Finally, regarding the policy implications, the introduction of policy programmes of local development that involve the introduction of material resources such as capital should also be accompanied with auxiliary strategies in order to generate desirable outcomes. Helping the NF to form collaborative alliances to increase their productive capacity is also applicable in this case. For the case of RRE farmers, these individuals would benefit from any policy programme that is accompanied with some sort of training in terms of technological and business aspects of the farm. This is because it was found that these individuals lacked experience and this was reflected in suboptimal decisions made by these farmers. Finally, the PRS farmers could be benefited by means of the introduction of activities that could help to motivate them to move towards the production of crops with higher levels of gross margin. Perhaps the development of seminars showing the case of successful farmers could be adopted as an auxiliary strategy for the PRS.
The present research offers a predictive behavioural model based on the results that could be used to identify types of farmers according to the Income-Risk Matrix typology (see Figure 7.21). This model could constitute a useful tool to provide guidance to policy makers in the design of policy programmes in terms of including auxiliary strategies suitable for specific types of farmers.

8.6 Weakness and Strengths of the Investigations, and Recommendations for Future Research

The main weakness of the present research is the small sample used to test the hypotheses established in the investigation. The main implication of using a small sample is that it is difficult to generalise the findings to explain farmers’ behaviour in a wider context. In addition, while it was possible to identify different classes of farmers in terms of their strategic behaviour in response to the removal of material resource restrictions, one class included only a single farmer. This made it impossible to conduct inferential statistics to determine the non-economic variables that influenced the strategic choice made by this farmer. It is important to clarify, however, that several attempts were made to obtain a larger sample. The main reason why these attempts were unsuccessful was because no list of ex-sugar beet farmers in the West Midlands was available in the public domain, and private institutions were unwilling to reveal this information. As a consequence, complementary sampling strategies were adopted. The small sample was obtained over a period of six months and was considered as the best option given the budget and timing constraints of the project. It is important to emphasise that the results obtained in this thesis could be biased to some extent as a
result of the snow ball technique adopted in this research. That is, in this technique farmers suggest friends meaning that individuals in the sample could be like minded. As a consequence, the results could reflect the behaviour of a liked minded fraction of ESBF rather than the behaviour of the population. This is why the results have to be considered with caution.

On the other hand, the main strength of the research is that it developed a rigorous novel theoretical development that was used to infer behavioural responses using a holistic approach. The results obtained in this thesis provided useful insights into the way in which farmers made their cropping decisions, and were highly consistent with this theoretical development.

Even though the results may not be generalised given the small sample used in the research, the novel theoretical approach and the novel analytical method developed in this thesis can be used to study any type of farmer and this is the main contribution of the current investigation. In other words, the main contribution of this thesis is not the results itself, but the methodological and theoretical approach developed within the research (see Sections 8.2.2, 8.3.5, and 8.4.2). This is because this approach not only captures economic drivers in explaining farmers’ cropping decisions as the traditional research does, but also different psychological, social and market considerations.

The research developed in this thesis can be extended in many directions. Three different possible extensions are discussed as follows. Firstly, it would be interesting to apply the proposed multivariate model to the study of the strategic cropping behaviour of farmers operating in different regions in the UK. This is because different regions normally have different characteristics and this, in turn, can affect farmers’ cropping
decisions. For example, a farmer who works in Suffolk County probably has an incentive to produce sugar beet because the sugar beet factory located in Bury St Edmunds is still in operation. In contrast, as shown in this investigation, farmers operating in the West Midlands had to replace this crop after the closure of the factory located at Allscott. This example suggests that the existence of market barriers such as lack of buyers for some crops can strongly affect farmers’ strategic behaviour. Differences of social-psychological drivers or material resource constraints across regions could also affect farmers’ strategic behaviour. For example, attitudes toward the production of a particular crop could be influence by farmers’ belief of their capacity to control the associated productive process. This belief, in turn, could be influenced by geographical location because some areas in the UK have less favourable climatic and soil conditions for the production of some crops. To see that, consider the case of erosion presented in Figure 8.1:
Figure 8.1: Areas of most at risk from erosion. Source: Department for Environment Food and Rural Affairs (2005).
This figure shows that erosion by water and wind is heterogeneously distributed across the UK. Because erosion negatively affects the productivity of different crops, this example suggests that geographical location could affect farmers’ cropping decisions. For example, an important decision in this context is the adoption of permanent grass or wood land to prevent severe water erosion (Department for Environment Food and Rural Affairs, 2005). Consequently, the area of land covered with crops by a particular farmer will be affected if this individual decides to adopt wood land to prevent erosion.

Secondly, the proposed multivariate model could be use to study farmers’ decision making of individuals who develop different businesses. To see the potential of this investigation, consider the following example. In the UK cropping farmers are subdivided in three types: (i) cereal farms (i.e. farms on which cereals, oilseeds, peas and beans harvested dry and land set aside account for over two-thirds of their total standard gross margin); (ii) general cropping farms (i.e. Farms with over two-thirds of their total standard gross margin in arable crops or a mixture of arable and horticultural crops; and holdings where arable crops account for more than one-third of total standard gross margin and no other grouping accounts for more than one-third); and (iii) horticulture farms (i.e. Farms where fruit, hardy nursery stock, glasshouse flowers and vegetables, market garden scale vegetables and outdoor bulbs and flowers account for more than two thirds of total standard gross margin) (Department for Environment Food and Rural Affairs, 2010c). The evolution of the number of holdings of these types of farms in the West Midlands region is shown in Figure 8.2:
According to this figure, the number of horticulture farm holdings in the West Midlands region has remained relatively stable since year 2000. In contrast, the number of cereal farm holdings has increased and the number of general cropping farm holdings has decreased since 2000. These trends suggest that a number of general cropping farms have replaced their productive plans through the years and, apparently, they have become cereal farmers. However, it is not clear why some individual still remain as general cropping farms, why others have replaced their productive plans, and why the number of horticultural farms have remained relatively stable. The proposed multivariate model developed in this thesis could be applied to understand these differences. As shown in this thesis, the proposed model can be used to identify subclasses of farmers. Consequently, subclasses of general cropping framers could be identified and this information could be used to predict which of these farmers will probably turn into cereal farms. Likewise, the proposed model can be used to identify
economic and non-economic drivers explaining why horticultural farms are apparently a stable group. Information of economic and non-economic drivers explaining the motivations of these types of farmers could also be used to predict their possible responses to policy changes as shown in Chapter Seven of this thesis. Behavioural predictions, in turn, could eventually assist policymakers in the design of suitable strategies for local development focused on specific group targets.

Finally, the proposed multivariate model could be used to study cross cultural influences on the strategic behaviour of farmers working in different countries. For example, Shucksmith et al. (2006) argue that cultural diversity among rural areas within Europe can be identified from the following sources: (i) different historical legacies in terms of the dominance of agricultural production; (ii) distinctive space organisation which is associated with different manifestations of social exclusion and quality of life; and (iii) people’s rural social constructions which influence their own actions. All these sources probably affect farmers’ strategic behaviour and this could probably be captured as different strategic choices made by farmers in different countries. The proposed multivariate model could be use to study these differences and to cluster farmers according to similar strategic behaviour. The model could also be used to identify economic and non-economic drivers that characterise each of these clusters. This information, in turn, could be used by policy makers to predict possible farmers’ behavioural responses to future policy reforms introduced by the European Union.

As show in these examples, the proposed multivariate model has high potential to be extended in many ways and in different contexts. All these important possible extension are left for future research.
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407


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Appendix A

Geographical characteristics of the West Midlands region

The West Midlands is a region that covers 13,000 square kilometres and has a population of approximately 5.3 million people, of which 20% live in rural areas (Ministry of Agriculture, Fisheries and Food, 2000). This region is composed of 6 counties: Herefordshire, Worcestershire, Warwickshire, Shropshire, Staffordshire, and West Midlands. According to Ministry of Agriculture, Fisheries and Food (2000), 80% of the land in the West Midland is used in agriculture. This activity is found mainly in five Counties (Herefordshire, Worcestershire, Warwickshire, Shropshire and Staffordshire) and seven Unitary Authorities (Telford and Wrekin, Stoke-On-Trent, Birmingham, Solihull, Coventry, Dudley and Sandwell, and Walsall and Wolverhampton). Table A.1 shows the relative importance of these Counties and Unitary Authorities in terms of farmed land area.

<table>
<thead>
<tr>
<th>County/Unit Authority</th>
<th>Farmed Area (hectares)</th>
<th>Share with respect to the West Midlands (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herefordshire</td>
<td>180,324</td>
<td>18.8</td>
</tr>
<tr>
<td>Worcestershire</td>
<td>127,999</td>
<td>13.3</td>
</tr>
<tr>
<td>Warwickshire</td>
<td>149,656</td>
<td>15.6</td>
</tr>
<tr>
<td>Telford and Wrekin</td>
<td>18,767</td>
<td>2.0</td>
</tr>
<tr>
<td>Shropshire</td>
<td>271,752</td>
<td>28.3</td>
</tr>
<tr>
<td>Staffordshire</td>
<td>193,654</td>
<td>20.2</td>
</tr>
<tr>
<td>Rest</td>
<td>16,667</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Source: Statistics provided by Department for Environment Food and Rural Affairs (2010b)

According to this table, Shropshire is the most intensively farmed county in terms of farmed area and is followed by Staffordshire, Herefordshire, Warwickshire and Worcestershire.
These counties and unitary authorities have some important differences in land quality, a fact that can be seen from the land quality criterion used in England. According to this criterion, the farmed land is classified according to a scale from 1 to 5, with land Grade 1 being the best, and land Grade 5 the worst. Land Grade 1 is suitable for the production of a wide range of agricultural and horticultural crops, and is normally used for the production of high value markets. Land Grade 2 has some minor limitations, but can still generate good yields. This land is usually covered with a wide range of crops such as potatoes, orchards and other horticultural crops. Land Grade 3 is a land of good to moderate quality, and can be found in heavier wetter soils typically under cereals or grassing, or in lighter solids covered with a more varied range of crops, but yields and crops choices are more restricted than the possibility options offered by lands Grades 1 and 2. Land Grade 4 is of poor quality and highly suitable for growing grass. Finally, land Grade 5 is the worst land in terms of quality and can be found in the highest and wettest part of the region. This land is only suitable for extensive grazing, primarily by sheep. Table A.2 shows the percentage of land with different land qualities in the West Midlands, and the most common localities where they can be found.

Table A.2 Percentage of land classification grade, and their common location

<table>
<thead>
<tr>
<th>Land Grade</th>
<th>Percentage with respect to the West Midlands</th>
<th>Common Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>Herefordshire and Worcestershire</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>Herefordshire and Warwickshire</td>
</tr>
<tr>
<td>3</td>
<td>48.0</td>
<td>Shropshire and Staffordshire</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>Welsh border and east Staffordshire Moorland</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>Highest and wettest parts of the region</td>
</tr>
</tbody>
</table>

Source: Statistics provided by Ministry of Agriculture, Fisheries and Food (2000)
### Appendix B

#### Land uses in the West Midlands region

Table B.1 Land uses for selected crops in the West Midlands (Hectares)

<table>
<thead>
<tr>
<th>Crop or Land Use</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar Beet</td>
<td>15,498</td>
<td>15,885</td>
<td>15,288</td>
<td>14,528</td>
<td>13,617</td>
<td>13,359</td>
<td>11,676</td>
<td>6,687</td>
</tr>
<tr>
<td>Wheat</td>
<td>166,719</td>
<td>129,390</td>
<td>162,540</td>
<td>150,249</td>
<td>167,356</td>
<td>157,429</td>
<td>154,504</td>
<td>153,292</td>
</tr>
<tr>
<td>Winter Barley</td>
<td>52,347</td>
<td>38,727</td>
<td>45,627</td>
<td>36,859</td>
<td>32,165</td>
<td>29,986</td>
<td>29,390</td>
<td>29,611</td>
</tr>
<tr>
<td>Spring Barley</td>
<td>19,553</td>
<td>38,142</td>
<td>19,944</td>
<td>24,769</td>
<td>20,833</td>
<td>20,165</td>
<td>16,959</td>
<td>18,106</td>
</tr>
<tr>
<td>Oats</td>
<td>14,819</td>
<td>15,897</td>
<td>18,197</td>
<td>17,199</td>
<td>14,515</td>
<td>12,242</td>
<td>16,993</td>
<td>19,142</td>
</tr>
<tr>
<td>Potatoes</td>
<td>19,653</td>
<td>19,487</td>
<td>18,135</td>
<td>16,432</td>
<td>17,230</td>
<td>16,360</td>
<td>16,407</td>
<td>16,212</td>
</tr>
<tr>
<td>Oilseed Rape</td>
<td>21,301</td>
<td>28,131</td>
<td>23,014</td>
<td>32,975</td>
<td>35,919</td>
<td>37,965</td>
<td>34,419</td>
<td>42,758</td>
</tr>
<tr>
<td>Maize</td>
<td>13,044</td>
<td>16,116</td>
<td>15,318</td>
<td>15,338</td>
<td>14,956</td>
<td>16,803</td>
<td>18,035</td>
<td>18,915</td>
</tr>
<tr>
<td>Root Crops*</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>2,117</td>
<td>2,214</td>
<td>3,148</td>
<td></td>
</tr>
<tr>
<td>Bare Fallow</td>
<td>2,372</td>
<td>2,795</td>
<td>2,001</td>
<td>1,928</td>
<td>2,264</td>
<td>11,600</td>
<td>11,214</td>
<td>13,444</td>
</tr>
<tr>
<td>Permanent Grass</td>
<td>361,792</td>
<td>381,574</td>
<td>359,223</td>
<td>384,049</td>
<td>382,102</td>
<td>359,906</td>
<td>419,355</td>
<td>420,879</td>
</tr>
<tr>
<td>Temporary Grass</td>
<td>92,547</td>
<td>92,466</td>
<td>93,769</td>
<td>91,579</td>
<td>97,900</td>
<td>89,525</td>
<td>84,904</td>
<td>89,941</td>
</tr>
<tr>
<td>Rough Grazing</td>
<td>20,148</td>
<td>20,937</td>
<td>21,340</td>
<td>20,340</td>
<td>20,223</td>
<td>18,137</td>
<td>19,043</td>
<td>15,708</td>
</tr>
<tr>
<td>Total Small Fruit</td>
<td>1,333</td>
<td>1,353</td>
<td>1,332</td>
<td>1,437</td>
<td>1,595</td>
<td>1,545</td>
<td>1,950</td>
<td>1,754</td>
</tr>
<tr>
<td>Total Farmed Area**</td>
<td>929,857</td>
<td>956,782</td>
<td>927,970</td>
<td>942,592</td>
<td>943,129</td>
<td>952,573</td>
<td>959,624</td>
<td>958,818</td>
</tr>
</tbody>
</table>

* The category Roots Crops also includes Brassicas and Fodder Beet.
** Total farmed area corresponds to the total area used in agriculture in the West Midlands.
Source: Statistics from Department for Environment Food and Rural Affairs (2010b).

Table B.2 Participation of land uses with respect to the total farmed area in the West Midlands (%)

---

440
<table>
<thead>
<tr>
<th>Crop or Land Use</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar Beet</td>
<td>1.7</td>
<td>1.7</td>
<td>1.6</td>
<td>1.5</td>
<td>1.4</td>
<td>1.4</td>
<td>1.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Wheat</td>
<td>17.9</td>
<td>13.5</td>
<td>17.5</td>
<td>16.0</td>
<td>17.7</td>
<td>16.5</td>
<td>16.1</td>
<td>16.0</td>
</tr>
<tr>
<td>Winter Barley</td>
<td>5.6</td>
<td>4.0</td>
<td>4.9</td>
<td>3.9</td>
<td>3.4</td>
<td>3.1</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Spring Barley</td>
<td>2.1</td>
<td>4.0</td>
<td>2.1</td>
<td>2.6</td>
<td>2.2</td>
<td>2.1</td>
<td>1.8</td>
<td>1.9</td>
</tr>
<tr>
<td>Oats</td>
<td>1.6</td>
<td>1.7</td>
<td>2.0</td>
<td>1.8</td>
<td>1.5</td>
<td>1.3</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Potatoes</td>
<td>2.1</td>
<td>2.0</td>
<td>2.0</td>
<td>1.7</td>
<td>1.8</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Oilseed Rape</td>
<td>2.3</td>
<td>2.9</td>
<td>2.5</td>
<td>3.5</td>
<td>3.8</td>
<td>4.0</td>
<td>3.6</td>
<td>4.5</td>
</tr>
<tr>
<td>Maize</td>
<td>1.4</td>
<td>1.7</td>
<td>1.7</td>
<td>1.6</td>
<td>1.6</td>
<td>1.8</td>
<td>1.9</td>
<td>2.0</td>
</tr>
<tr>
<td>Root Crops*</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Bare Fallow</td>
<td>0.3</td>
<td>0.3</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Permanent Grass</td>
<td>38.9</td>
<td>39.9</td>
<td>38.7</td>
<td>40.7</td>
<td>40.5</td>
<td>41.6</td>
<td>43.7</td>
<td>43.9</td>
</tr>
<tr>
<td>Temporary Grass</td>
<td>9.95</td>
<td>9.7</td>
<td>10.1</td>
<td>9.7</td>
<td>10.4</td>
<td>9.4</td>
<td>8.8</td>
<td>9.4</td>
</tr>
<tr>
<td>Rough Grazing</td>
<td>2.2</td>
<td>2.2</td>
<td>2.3</td>
<td>2.2</td>
<td>2.1</td>
<td>1.9</td>
<td>2.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Total Small Fruit</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.02</td>
</tr>
</tbody>
</table>

* The category Roots Crops also includes Brassicas and Fodder Beet.

Source: Developed by the author with statistics of Department for Environment Food and Rural Affairs (2010b).

Note that according to Table B1, the number of hectares of maize increased from year 2003. In terms of the participation of land uses with respect to the total farmed area in the West Midlands, the participation of maize increased from 2005. According to Bryson and Taylor (2006) and Department for Environment Food and Rural Affairs (2007), this increase in the production of maize was linked to the trend of the dairy sector towards fewer but larger farms concentrated in lowland areas.

**Appendix C**
Numerical Example of the Relationship between the Bernoulli Utility Function and the Expected Utility Function

The objective of this appendix is to clarify the difference between the *Bernoulli utility function* and the *expected utility function* by using a numerical example. For this purpose, consider the information presented in the following Table.

<table>
<thead>
<tr>
<th>Gross Margin ($\pi$)</th>
<th>Concave Bernoulli Utility Function $U(\pi) = \ln(\pi)$</th>
<th>Convex Bernoulli Utility Function $U(\pi) = 2 + \pi + 5\pi^2$</th>
<th>Linear Bernoulli Utility Function $U(\pi) = \pi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_L = 10.0$</td>
<td>$U(\pi_L) = 2.3$</td>
<td>$U(\pi_L) = 30.8$</td>
<td>$U(\pi_L) = 10.0$</td>
</tr>
<tr>
<td>$\pi_U = 40.0$</td>
<td>$U(\pi_U) = 3.7$</td>
<td>$U(\pi_U) = 73.7$</td>
<td>$U(\pi_U) = 40.0$</td>
</tr>
</tbody>
</table>

The first column of this table considers two states of nature: the unfavorable state of nature (i.e. $\pi_L$); and the favorable state of nature (i.e. $\pi_U$). According to this table, the individual obtains a gross margin equal to £10 when the unfavorable state of nature is verified; and a gross margin equal to £40 when the favorable state of nature is verified.

When the unfavorable state of nature is verified, an individual who has a concave utility function (second column of Table C.1) obtains a level of utility equal to 2.3; an individual who has a convex utility function (third column of Table C.1) obtains a level of utility equal to 30.8; and an individual who has a linear utility function (fourth column of Table C.1) obtains a level of utility equal to $10^{17}$. In contrast, if the favorable state of nature is verified, an individual who has a concave utility function obtains a level of utility equal to 3.7; an individual who has a convex utility function obtains a level of utility equal to $10^{17}$.
level of utility equal to 73.7; and an individual who has a linear utility function obtains a level of utility equal to 40.

This is the information needed to calculate expected utility. As explained in Section 3.3.2.1, this utility is a weighted average of the outcomes of the states of nature. These states are weighted by their probability of occurrence. An example of how the expected utility is calculated using the information presented in Table C.1 is shown in Table C.2 as follows:

Table C.2 Calculating the Expected Utility Function

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( \theta )</td>
<td>( (1 - \theta) )</td>
<td>( E(U(\pi)) = \theta \cdot \text{Ln}(\pi_L) + (1-\theta) \cdot \text{Ln}(\pi_U) )</td>
<td>( E(U(\pi)) = \theta \cdot (2 + \pi_L + 5 \pi_L^2) + (1-\theta) \cdot (2 + \pi_U + 5 \pi_U^2) )</td>
</tr>
<tr>
<td>0.2</td>
<td>0.8</td>
<td>( E(U(\pi)) = 3.4 )</td>
<td>( E(U(\pi)) = 65.1 )</td>
</tr>
<tr>
<td>0.4</td>
<td>0.6</td>
<td>( E(U(\pi)) = 3.1 )</td>
<td>( E(U(\pi)) = 56.6 )</td>
</tr>
<tr>
<td>0.6</td>
<td>0.4</td>
<td>( E(U(\pi)) = 2.9 )</td>
<td>( E(U(\pi)) = 48.0 )</td>
</tr>
<tr>
<td>0.8</td>
<td>0.2</td>
<td>( E(U(\pi)) = 2.6 )</td>
<td>( E(U(\pi)) = 39.4 )</td>
</tr>
</tbody>
</table>

The first two columns of this table show the probabilities of outcomes \( \pi_L \) and \( \pi_U \), respectively. Using these probabilities, it was possible to calculate the expected utility for three individuals: one who has a concave Bernoulli utility function (third column in Table C.2); one who has a convex Bernoulli utility function (fourth column in Table C.2); and one who has a linear Bernoulli utility function (fifth column in Table C.2). These three expected utility functions are depicted in Figure C.1.
As explained in Section 3.3.2.1, the main characteristics of the expected utility function is that it is always a linear function, independently of the shape of the Bernoulli utility function, because it represents a linear combination of outcomes (or weighted average of outcomes). This is why the expected utility functions derived from the Bernoulli utility functions presented in Table C.1 are linear. As shown in Figure C.1, the shape of the Bernoulli utility function only affects the slope of the expected utility, but not its shape. This is why the three expected utility functions depicted in this figure have different slopes: they were derived from three different Bernoulli utility functions.

Appendix D

The Meaning of the Coefficient of Absolute Risk Aversion
As explained in Section 3.3.2.1, attitudes towards risk are captured by the coefficient of risk aversion denoted by $r_a$. This coefficient is defined by following formula: $r_a = -U''(\pi)/U'(\pi)$, where $U'(\pi)$ and $U''(\pi)$ denote the first and second derivatives of the Bernoulli utility function (Bar-Shira et al., 1997).

This coefficient involves two relevant indicators: the negative sign; and the division between the change of the slope of the Bernoulli utility function (i.e. the second derivative of this utility function, $\frac{\partial^2 U(\pi)}{\partial \pi^2} = U''(\pi)$) and the slope itself (i.e. the first derivative of the Bernoulli Utility function, $\frac{\partial U(\pi)}{\partial \pi} = U'(\pi)$). Two understand the information that is associated with these indicators, consider the cases depicted in Figure D.1:

Figure D.1: Different types of Bernoulli Utility Functions

Let us first consider Figure D.1(a) to explain the objective of the negative sign in the coefficient of absolute risk aversion. This figure shows three types of Bernoulli utility functions: (i) a concave utility function (curve A in the figure); (ii) a convex utility
function (curve B in the figure); and (iii) a linear utility function (curve C in the figure). The slope of these three utility functions (i.e. the first derivative) is positive because in all of them utility increases as gross margin increases. Let $U' (\pi)_A$, $U' (\pi)_B$, $U' (\pi)_C$, be the slopes or first derivatives of the Bernoulli utility functions A, B and C, respectively. Because it is verified in these utility functions that utility increases as gross margin increases, it holds that $U' (\pi)_A > 0$, $U' (\pi)_B > 0$ and $U' (\pi)_C > 0$. On the other hand, note that the Bernoulli utility function A increases at a decreasing rate (i.e. it is a concave function). That is, the positive slope of this function decreases as gross margin increases. Because this change in the slope is captured by the second derivative of the utility function, it is concluded that $U'' (\pi)_A < 0$. The Bernoulli utility function B, in contrast, increases at an increasing rate as gross margin increases (i.e. it is a convex function). This implies that its slope increases as gross margin increases, and this is captured as a positive second derivative. That is, in this case it holds that $U'' (\pi)_B > 0$. Finally, the Bernoulli utility function C increases at a constant rate (i.e. it is a linear function). Consequently, its slope is constant implying that the second derivative of this utility function is equal to zero. That is, it holds that $U'' (\pi)_C = 0$. This information is summarised in Table D.1.

Table D.1. Signs of the first and second derivatives, and Coefficient of Absolute Risk Aversion.

<table>
<thead>
<tr>
<th>Bernoulli Utility Function</th>
<th>First derivative $U'(\pi)$</th>
<th>Second derivative $U''(\pi)$</th>
<th>Division between second and first derivatives</th>
<th>Coefficient of Absolute Risk Aversion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

446
The second column of this table shows the sign of the first derivative of the Bernoulli utility functions A, B and C depicted in Figure D.1(a). As explained above, this derivative is positive because in all these functions it is verified that utility increases as gross margin increases. The third column shows the sign of the second derivative. Because the Bernoulli utility A increases at a decreasing rate (i.e. because this function is concave), its second derivative is negative. In contrast, because the Bernoulli utility B increases at an increasing rate (i.e. because this function is convex), its second derivative is positive. Finally, because the Bernoulli utility C increases at a constant rate (i.e. because this function is linear), its second derivative is equal to zero. Column fourth shows the sign of the division between the second and the first derivatives for the Bernoulli utility functions A, B, C. Because the second derivative of the utility function A is negative and the first derivative is positive, this division is in this case negative. In contrast, this division is positive for the utility function B, and zero for the utility function C. Finally, the last column introduces a negative sign in order to change the sign of the divisions presented in the fourth column. This is the coefficient of absolute risk aversion. The negative sign is used to have a positive coefficient for concave functions such as the Bernoulli utility function A. Because this function is presented in individuals who are risk averse (see the discussion given in Section 3.3.2.1), a positive
coefficient of absolute risk aversion (i.e. $r_a > 0$) means that the individual is risk averse. Likewise, the negative sign introduced in the last column of Table D.1 is used to have a negative coefficient of absolute risk aversion for convex functions such as the Bernoulli utility function B. As discussed in Section 3.3.2.1, this function is presented in individuals who are risk lovers (or risk takers). Consequently, a negative coefficient of absolute risk aversion (i.e. $r_a < 0$) represents an individual who is risk lover. Finally, this coefficient is equal to zero (i.e. $r_a = 0$) when the Bernoulli utility is linear. As explained in Section 3.3.2.1, this is because an individual who has this Bernoulli utility function is indifferent between obtaining a certain amount of gross margin under either certainty or uncertainty. This information is summarised in Table D.2.

<table>
<thead>
<tr>
<th>Sign of the Coefficient of Absolute Risk Aversion $r_a$</th>
<th>Type of Bernoulli Utility Function</th>
<th>Attitude Towards Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r_a &gt; 0$</td>
<td>Concave</td>
<td>Risk Averse</td>
</tr>
<tr>
<td>$r_a &lt; 0$</td>
<td>Convex</td>
<td>Risk Lover</td>
</tr>
<tr>
<td>$r_a = 0$</td>
<td>Linear</td>
<td>Risk Neutral</td>
</tr>
</tbody>
</table>

On the other hand, the division between the second and the first derivative of the Bernoulli utility function (i.e. $U''(\pi)/U'(\pi)$) is used to capture the degree of concavity of this function. To see why, let us consider the example presented in Figure D.1(b). This figure shows two concave Bernoulli utility functions referred to as functions D and E. Because both of them are concave, they both are associated with individuals who are risk averse. This means that the coefficient of absolute risk aversion in both functions is positive. The utility function E is however more concave than the function D meaning...
that the individual who has the utility function E is even more risk averse. As shown in the discussion that follows, this higher degree of concavity is captured by the division $U''(\pi)/U'(\pi)$. In order to facilitate this explanation, the absolute value of this division will be considered: $|U''(\pi)/U'(\pi)|$. Figure D.1(b) shows that the slope of the functions D and E is the same at point $a$. However, the slope of the later decreases faster than the slope of function D as gross margin increases. As a consequence, the slope of function E at point $b$ is smaller than the slope of function D at point $c$. Because the change in the slope is captured by the second derivative of the utility function, it is concluded therefore that $|U''(\pi)_E| > |U''(\pi)_D|$ because the slope of the the utility function E decreases faster. Note, on the other hand, that the slope of the utility function E is always smaller than the slope of the utility function D after point $a$. This is a consequence of the faster decrease of the slope verified in function E. This implies that $|U'(\pi)_E| < |U'(\pi)_D|$. Now, because $|U''(\pi)_E| > |U''(\pi)_D|$ and $|U'(\pi)_E| < |U'(\pi)_D|$, the division $|U''(\pi)_E/U'(\pi)_E|$ is always larger than the division $|U''(\pi)_D/U'(\pi)_D|$ because a division having a larger numerator and a smaller denominator is always larger. This confirms the fact that the division between the second and the first derivative of a function is a measure of the concavity of this function. Finally, because $|U''(\pi)_E/U'(\pi)_E| > |U''(\pi)_D/U'(\pi)_D|$, it is concluded that the coefficient of absolute risk aversion obtained from the utility function E (i.e. $r_{ae}$) is larger than the coefficient obtained from function D (i.e. $r_{ad}$). This also confirms the fact that the individual who has the utility function with higher degree of concavity is more risk averse.

In summary, if $r_{ae} > r_{ad} > 0$, then the utility function E is more concave than the utility function D, and this means that the individual who has the first function is more risk averse.

449
Note that a similar analysis can be conducted for the case of a risk lover individual. However, the interpretation in this case has to be considered with caution because the coefficient of absolute of risk aversion for these individuals is negative. That is, an individual is more risk lover when he/she has a Bernoulli utility function with a higher degree of convexity. As an example, suppose that a risk lover individual has a Bernoulli utility function named function F, and another risk lover individual has a Bernoulli utility function named G. If the former is more risk lover, then the utility function F is more convex than function G. In this case, it is verified that \( |r_{af}| > |r_{ag}| > 0 \) (where \( |r_{af}| \) means the absolute value of \( r_{af} \) or alternatively \( r_{af} < r_{ag} < 0 \).

Appendix E

Calculating Expected Gross Margin, Variance and Efficient Frontier (EF)
The following example was introduced with the purpose of showing how the expected gross margin of the portfolio, the associated variance and the EF are calculated. Suppose that a determined farmer chooses a portfolio of crops formed of crops A and B. The expected gross margin of crop A is calculated by taking the average of the historical information of the gross margin of this crop obtained in the past over a determined period of time. This is because this average is used as an estimator of the future gross margin of this crop. This is why this average is referred to as the expected gross margin of crop A (see Dougherty, 2007). That is, it is assumed that the farmer has adaptive expectations because he/she uses historical information of gross margin of crop A obtained in the past to predict the future gross margin of this crop (this concept is explained in more detail in part (a) of Section 5.3.4.3). For instance, if the current year is 2011, and if the farmer wants to know the possible gross margin that he/she will obtain from crop A in year 2012, then she/he will consider an arbitrary interval of time, say, from 2006 to 2011 to make his/her expectation. In this case she/he will consider the average of the gross margin that this individual obtained from crop A in this interval of time\(^{18}\). Let \(GM_A\) be the weighted average of gross margin (or expected gross margin) of crop A. Likewise, let \(GM_B\) the expected gross margin of crop B.

The other information that is needed to calculate the EF is the variance of gross margin of these crops. This variance for crop A is obtained by calculating the variance of the gross margin of this crop over the period of time considered when calculating the expected gross margin. In this example, this variance is calculated using historical data of gross margin in the period of time between 2006 and 2011. Let \(V_A\) and \(V_B\) be the variances of the gross margin of crops A and B, respectively.

\(^{18}\) Some more elaborated versions of the adaptive expectations hypothesis consider a weighted average of past gross margins. In these versions higher weights are put in later years with the purpose of capturing the fact that recent realisations of gross margin are more informative (for a discussion, see Dougherty, 2007).
It is important to clarify that $GM_A$, $GM_B$, $V_A$, and $V_B$ are given because they depend on past realisations of gross margin. This implies that the control variables available for the farmer are the weights that he/she assigns to crops A and B in the portfolio of crops. That is, the only way to modify the expected value and the variance of the gross margin of the portfolio is by changing these weights (i.e. by changing the mix of crops). Let $\phi$ be the weight that the farmer puts on crop A in the portfolio (this weight represents the proportion of land occupied by this crop), and let $(1 - \phi)$ be the weight that this individual puts on crop B. Let $GM_P$ be the expected gross margin of the portfolio of crops. This indicator is obtained by calculating the weighted average of the expected gross margin of the single crops that compose the portfolio. That is, $GM_P = \phi*GM_A + (1 - \phi)*GM_B$. The variance of the gross margin of the portfolio, denoted by $V_P$, is calculated from the last equality as follows: $V_P = \phi^2*V_A + (1 - \phi)^2 + 2*\phi*(1 - \phi)*Cov(A;B)$, where $Cov(A;B)$ is the covariance between the gross margins of crops A and B. The EF is obtained by calculating different levels of $GM_P$ and $V_P$ from different values of $\phi$ and $(1 - \phi)$. In order to clarify this concept, a numerical example is provided in Table E.1 as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Gross Margin Crop A (£/ha)</th>
<th>Gross Margin Crop B (£/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>100</td>
<td>95</td>
</tr>
<tr>
<td>2007</td>
<td>115</td>
<td>98</td>
</tr>
</tbody>
</table>

Table E.1. Hypothetical information of gross margin of crops A and B.
2008  90  85
2009  98  100
2010  120  105
2011  125  90

Average of Gross Margin  $\text{GM}_A = 108$
Variance of Gross Margin  $V_A = 194$

Covariance between Gross Margin of crops A and B: where $\text{Cov}(A;B) = 37$

According to this table, the expected gross margins of crops A and B are 108 and 96, respectively. The variances of the gross margin of these crops are 194 and 52, respectively. Finally, the covariance between the gross margins of crops A and B is 37. This is the information that is needed to calculate the EF for the portfolio of crops composed of crops A and B. Table E.2 shows different magnitudes of $\text{GM}_P$ and $V_P$ that were calculated using different values of $\phi$ and $(1 - \phi)$ in the formulas described above (i.e. $\text{GM}_P = \phi \cdot \text{GM}_A + (1 - \phi) \cdot \text{GM}_B$ and $V_P = \phi^2 \cdot V_A + (1 - \phi)^2 \cdot V_B + 2 \cdot \phi \cdot (1 - \phi) \cdot \text{Cov}(A;B)$):

| Weight on Crop A | Weight on Crop B
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi$</td>
<td>$(1 - \phi)$</td>
</tr>
<tr>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>Expected Gross Margin of the Portfolio: $\text{GM}_P$</td>
<td>98.4</td>
</tr>
<tr>
<td>Variance of the Portfolio: $V_P$</td>
<td>52.9</td>
</tr>
</tbody>
</table>

The numbers in the last two columns of this table define the EF associated with the portfolio of crops formed of crops A and B. This relationship is depicted in Figure E.1.
Figure E.1: The Efficient Frontier for the Portfolio Composed of Crops A and B.

In this figure, Point 2 is obtained by occupying 40% of the land with Crop A and 60% with Crop B (see Table E.2). Using this combination in the portfolio of crops the farmer obtains a level of expected gross margin equal to 100.8 and a variance equal to 67.5. In contrast, Point 4 for example is obtained by occupying 80% of the land with Crop A and 20% with Crop B (see Table E.2). Using this combination in the portfolio of crops the farmer obtains a level of expected gross margin equal to 105.6 and a variance equal to 138.1.

Note an important fact associated with the EF presented in Figure E.1. A farmer who wants to increase the expected gross margin of the portfolio by placing more weight in Crop A has to face a higher level of variance which is considered in this context as a measure of business risk (see Footnote 2 in Chapter Two). This implies that the position that a farmer chooses on the EP will depend on his/her attitude towards risk. In the figure, these positions are given by points 1, 2, 3 and 4. A farmer who chooses Point 4
is less risk averse than a farmer who chooses Point 2 because the former is willing to face more risk (a higher variance of the gross margin of the portfolio) by covering 80% of the land with Crop A (i.e. $\phi = 0.8$) and 20% of the land with Crop B (i.e. $(1 - \phi) = 0.2$). Figure E.2 shows the case of an individual who maximises his/her expected utility at Point 2, where the $EF$ is tangent to the indifference curve. In order to obtain this optimum point, this individual has to form a portfolio of crops by occupying 40% of the land with Crop A and 60% with Crop B.

Figure E.2: The case of the farmer who maximises his expected utility at Point 2.

**Appendix F**

**Relationship between the SEU and the EV**
As shown below, the $E(U(\pi))_{EV}$ described in Equation iv in Section 3.3.2.3 is derived from a Bernoulli utility function. Because the latter is a component of the $E(U(\pi))_{SEU}$ presented in Expression (iii) in Section 3.3.2.3, this means that the $E(U(\pi))_{SEU}$ and the $E(U(\pi))_{EV}$ are both related by the Bernoulli utility function. This relationship is explained as follows.

Technically, the SEU and the EV are related by the Bernoulli utility functions. The most common of these functions that researchers have adopted to study decision making under uncertainty are the quadratic utility function (QUF) and the exponential utility function (EUF) (Hardaker et al., 1997; and Lambert and McCarl 1985). The QUF, given by $U(\pi) = \alpha \pi + \beta \pi^2$, is related to the SEU due to its concavity defined by the sign of the coefficients $\alpha$ and $\beta$. To illustrate this, it is important to note that the coefficient of absolute risk aversion associated with this function is $r_a = -2\beta/(\alpha + 2\beta\pi)$ (see Section 3.3.2.1 and Appendix D). It is easy to demonstrate that this coefficient is positive when $\beta < -\alpha/2\pi$. Thus, when this condition is satisfied, this farmer is risk averse meaning that this individual prefers not to play games involving uncertainty (see Figure 3.4(a)). This function is also related to the EV because its expected value corresponds to which has a similar functional form than Expression iv presented in Section 3.3.2.3.

$$E(U(\pi)) = \alpha E(\pi) + \beta V(\pi)$$  \hspace{1cm} (F.1)

where $E(\pi)$ and $V(\pi)$, as explained above, are the expected value and the variance of gross margin. That is, the $E(U(\pi))$ defines the EV framework. Note that this function is presented in Figure 3.5 in Section 3.3.2.2 as a straight line representing a particular value of the expected utility given by the indifference curve $E(U(\pi))_0$. In particular, this figure shows the case of a risk averse farmer in which $\alpha > 0$ and $\beta < 0$ in equation F.1.
That is, this case shows an individual whose utility increases when gross margin increases (i.e. $\alpha > 0$), and decreases when business risk increases (i.e. $\beta < 0$). On the other hand, the EUF, given by $U(\pi) = 1 - e^{\gamma \pi}$, is also related to the SEU due to its concavity which is defined by the sign of the coefficient $\gamma$. To indicate this, notice that the coefficient of absolute risk aversion associated with this function is given by $r_a = \gamma$. Therefore, when $\gamma > 0$, this farmer is risk averse implying that this individual prefers not to play games involving uncertainty (see Figure 3.4(a)). This function can also be linked to the EV when using a second order Taylor expansion which corresponds to:

$$E(U(\pi)) = E(\pi) - r_a V(\pi)/2$$

where, as explained above, $r_a$ denotes the absolute coefficient of absolute risk aversion. This is actually the expression presented in Equation iv.

Appendix G

Abstracts of Articles Accepted in Per Reviewed Journals and Conferences

Abstract: It is a well known fact that in many situations farmers consider market risk when making their economic decisions. Unfortunately the existing economic frameworks that incorporate this type of risk and that may be incorporated into biophysical economic models have important potential biases that can affect their predictive power. The objective of this paper is to provide a critical review of these approaches and to propose a novel technique that can be used to minimise these potential biases. The paper finishes with the analysis of a pilot study that provides some empiricial support to the underlying theory of our technique.


Abstract: It is recognized that participation in networks in the agro-food chain provides farmers important opportunities to innovate. This is particularly important for small agricultural firms because these organizations face barriers that prevent them from innovating by means of some specific sources that are available in other industries. Surprisingly, no research has been developed to understand what motivates farmers to be involved in these networks. The paper fills this gap by proposing a decision making multivariate model. A probit analysis based on the proposed model revealed that farmers’ decision on participating in networks depends on goals and socio-psychological variables (non-economic drivers).


Abstract: Empirical evidence in the sugar sector of the UK revealed that farmer in this country adjusted to the reform of the Sugar Regime either by diversifying production or by specialising in few crops. This article hypothesises that these strategic choices were influenced by a number of economic and non-economic drivers. A probit analysis conducted with a sample of ex-sugar beet farmers was used to test this hypothesis. The result showed that only non-economic drivers (i.e. social-psychological variables) were significant in explained farmers’ strategic choice. This suggests that traditional analyses based on pure economic considerations have to be considered with caution.


Abstract: Cooperative alliances are considered as useful business strategies to reduce costs and to increase negotiation power. However, these alliances are not common in some regions of the UK. The paper proposes a new multivariate model based on the theory of planned behaviour to test the hypothesis that the importance that farmers attribute to cooperative alliances is determined by economic and social-psychological
variables. Evidence supporting this hypothesis was found from a sample of ex-Sugar Beet farmers of the West Midlands of the UK. This finding provides an additional explanation for the cooperation failure in this country.


**Abstract:** Researchers have identified a number of drivers of innovative capacity in rural areas such as farmers’ participation in social and commercial networks; farmers’ participation in collaborative alliances; farmers’ level of education; and farm-size. The present article extends this traditional research with the objective of determining whether these drivers also favour innovative capacity in turbulent market conditions (i.e. dynamic business environments) caused by policy changes. A probit analysis based on a proposed model of innovation revealed that not all these drivers were significant. Moreover, it was found that the capacity to innovate was also influenced by psychological variables.


**Abstract:** Goyal and Joshi (2003) proved that when firms form collaborative alliances with the objective of reducing production costs, the unique stable architecture of collaboration is the complete network (i.e. a network in which all firms have a collaborative alliance with one another). This article shows that this result does not hold when firms face distrust among potential partners. Since researchers have identified distrust as an important feature in agriculture, this finding suggests that the formation of beneficial collaborative alliances in this sector requires political intervention.


**Abstract:** A relatively new research has introduced non-economic drivers to explain farmers’ strategic behaviour with the objective of gaining an understanding of the way in which farmers adjust in response to policy reforms. In this context, it has been argued that these non-economic drivers remain robust through changes in policy and business environments because they represent long term enduring aspirations. The objective of this article is to test whether these drivers really remain robust to policy changes. For this purpose, a number of farmers were asked to report their attitudes towards specialisation before and after the incidence of a particular policy reform. The results revealed that only few drivers remained robust, but others were strongly affected by the reform.

**Appendix H**

**Derivation of the Efficient Portfolio Line**
According to the Multiple Efficient Frontiers Theory (MEFT) developed in this thesis, a negative relationship between expected gross margin and business risk (measured as the variance of gross margin as defined in Footnote 2 in Chapter Two) arises under some specific assumptions. This relationship was named in this thesis the Efficient Portfolio Line (EPL) and is defined as the line that joins points reflecting optimal combinations of expected gross margin and business risk of the portfolios of crops chosen by farmers who: (i) face market and resources barriers preventing them from adopting crops with high levels of gross margin (i.e. the descriptive component of the MEFT); (ii) maximise expected gross margin and minimise business risk simultaneously. That is, they maximise an expected utility function defined under the EV approach (i.e. the behavioural component of the MEFT); and (iii) are risk averse and have the same coefficient of absolute risk aversion (see Section 4.3.1).

The objective of this appendix is to derivate the $EFL$ mathematically. For this purpose, the three assumptions described above were used to develop an economic mathematical model that is consistent with the MEFT.

**H.1 The Descriptive Component of the MEFT**

The descriptive component of the MEFT establishes that farmers who face different market and resource barriers preventing them from producing crops with high gross margin cannot face the same efficient frontiers (see Section 4.3.1.1). The MEFT postulates that these farmers, when having few cropping options, will choose those traditional crops that allow them to form portfolios with efficient frontiers that can help
them to achieve higher levels of expected gross and lower levels of business risk. This idea is captured in the following equation:

\[ E_i(\pi) = \frac{1}{\theta_i} \ln(V(\pi)) + \theta_i^n \]

This equation represents an efficient frontier faced by farmer \( i \). \( E_i(\pi) \) is the expected gross margin obtained by this farmer from his/her portfolio of crops; \( \theta_i \) is a parameter; and \( V(\pi) \) is the variance of the gross margin of the portfolio of crops\(^{19}\). In this model this variance is an indicator of business risk (see Footnote 2 in Chapter Two). The component \( \ln(V(\pi)) \) denotes the natural logarithm of \( V(\pi) \) and was introduced with the purpose of capturing the typical concavity of the efficient frontiers (see Figure 4.4 and 4.5). The parameter \( \theta_i \), on the other hand, is specific for each farmer and was included with the objective of introducing one of the assumption of the MEFT: farmers cannot face the same efficient frontier. This coefficient appears twice in this equation. One is dividing the term \( \ln(V(\pi)) \) and was introduced in this way in order to capture the fact that different efficient frontiers have different slope. For example, Figure 4.4 shows two efficient frontiers with different slopes. The coefficient also appears as an additive component expressed as \( \theta_i^n \). The idea of adding this term is to capture the fact that efficient frontiers located more far away from the horizontal axis report higher levels of expected gross margin per unit of business risk. That is, if \( \theta_i^n > \theta_j^n \), then the portfolio of crops chosen by farmer \( i \) has an efficient frontier located more far away from the horizontal axis than that of the portfolio chosen by farmer \( j \). Finally, the power \( n \) in the coefficient was introduced to capture non-linearity. The following example was

\(^{19}\) More complex versions of this function can be considered. However, the one presented in Equation E1 is relatively simple and useful to illustrate how the EPL is derive when the assumptions of the MEFT hold which is the objective of this appendix.
developed to clarify these concepts. Imagine an economy formed of four farmers referred to as \( i, j, k \) and \( l \). Assume that in this example \( n = 2 \) in Equation H1. Assume in addition that the values of the specific coefficient \( \theta_i \) for these farmers are 1, 1.5, 2 and 2.5, respectively. This information is summarised in Table E1.

Table H1. Values of \( \theta_i \) for Farmers \( i = 1, 2, 3 \).

<table>
<thead>
<tr>
<th>Farmer</th>
<th>Value of ( \theta_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>3</td>
<td>2.0</td>
</tr>
<tr>
<td>4</td>
<td>2.5</td>
</tr>
</tbody>
</table>

The following figure shows the efficient frontiers faced by these farmers with the information presented in Table H1 and under the assumption that \( n = 2 \).

Figure H1. Efficient frontiers faced by Farmers 1, 2, 3 and 4.
This figure shows that Equation H1 has the property of generating different efficient frontiers when assuming different values of \( \theta \). Let us now introduce the behavioural component of the MEFT into the mathematical model.

**H.2 The Behavioural Component of the MEFT**

The behavioural component of the MEFT postulates that farmers care about maximising gross margin and minimising business risk simultaneously. That is, it assumes that farmers maximise an expected utility function defined under the EV approach (see Section 3.3.2.2). This function is presented as follows (see Section 3.3.2.3):

\[
E_i(U(\pi)) = E(\pi) - \frac{r_a}{2} V(\pi)
\]

**H2**

Where \( E_i(U(\pi)) \) is the expected utility of Farmer \( i \) and \( r_a \) is the coefficient of absolute risk aversion (this coefficient is formally defined in Section 3.3.2.1 and Appendix D).

**H.3 The Consequential Component of the MEFT**

The consequential component of the MEFT establishes that the EPL arises as a consequence of the maximisation process of farmers who are risk averse and have the same coefficient of absolute risk aversion (provided that the descriptive and behavioural components of this theory are both verified). To see that, let us consider the optimisation problem of a particular farmer \( i \). Using Equations H1 and H2, this optimisation problem is defined as:
This maximisation problem says that the objective of farmer \( i \) is to maximise his/her expected utility subject to the efficient frontier that he/she faces (this is the standard assumption adopted by the traditional EV approach discussed in Section 3.3.2.2). Note that in this optimisation problem the descriptive component of the MEFT is implicitly captured by the efficient frontiers equation described in Expression H1. Likewise, the behavioural component of this theory is captured by the expected utility function described in Equation H2. As a consequence, it is expected to find that the solution of the maximisation problem described in H3 will originate the EPL when introducing the condition of same coefficient of absolute risk aversion. This problem is presented graphically in Figure H2:
Figure H2. Optimisation problem of Farmer $i$

According to this figure, the optimal levels of expected gross margin and business risk when solving the problem presented in H3 is found at the point where the indifference curve (i.e. the combination of expected gross margin and business risk that generate the same levels of expected utility) is tangent to the efficient frontier. The indifference curve is obtained from the expected utility function when fixing a level of expected utility. Let $E_i(U(\pi))$ be this fixed level of expected utility. By rearranging terms in Equation H2, the indifference curve is defined by:

$$E(\pi) = E_i(U(\pi)) + \frac{r_o}{2} V(\pi)$$  \hspace{1cm} \text{H4}$$

The first derivative (or slope) of this function with respect to $V(\pi)$ is given by:

$$\frac{\partial E(\pi)}{\partial V(\pi)} = \frac{r_o}{2}$$  \hspace{1cm} \text{H5}$$

On the other hand, the first derivative of the efficient frontier given in Equation H1 is:

$$\frac{\partial E_i(\pi)}{\partial V(\pi)} = \frac{1}{\theta} V(\pi)$$  \hspace{1cm} \text{H6}$$
As shown in Figure H2, the solution of the maximisation problem presented in Expression H3 is obtained when equalising the first derivatives presented in Expressions H5 and H6. This optimisation solution is given in Equation H7:

\[
\frac{r_a}{2} \frac{1}{\theta V(\pi)}
\]

From this expression, the optimal variance chosen by Farmer \( i \) is given by:

\[
V^*(\pi) = \frac{2}{\theta r_a}
\]

Let us not consider the role of maintaining fixed the coefficient of absolute risk aversion across farmers. From Equation H8 it is inferred that when this coefficient is fixed (i.e. when farmers have the same coefficient), the derivative of the optimal level of business risk with respect to \( \theta \) is:

\[
\frac{\partial V^*(\pi)}{\partial \theta} = -\frac{2}{\theta^2 r_a}
\]

The economic interpretation of this result is that when farmers have the same coefficient of absolute risk aversion (which makes it possible to obtain the result given in Equation H9), farmers who have portfolios of crops with efficient frontiers located more far away
from the horizontal axis (i.e. have higher values of the coefficient $\theta_i$) choose smaller levels of business risk in the optimum. This situation is shown in Figure H3:

This figure represents the result obtained in Expression H9. In this figure, if a particular Farmer $i$ maximises his/her expected utility at Point $a$ when facing the efficient frontier $EF_1$, then Farmer $j$ maximises his/her expected utility at Point $b$ when facing the efficient frontier $EF_2$. Point $a$ reports a business risk equal to $V(\pi)_1$ which is larger than the business risk obtained at Point $b$ as described by Equation H9.

This is in essence the idea behind the $EPL$. That is, when the assumptions of the MEFT hold, farmers reduce business risk when being able to reach efficient frontiers located more far away from the horizontal axis. However, this is only one of two relevant
aspects associated with this curve. The other one is that farmers also increase the expected gross margin of their portfolios when being able to reach these efficient frontiers under some realistic assumptions. This second result is obtained when introducing the optimal solution given in Expression H8 into Expression H1. The resulting equation is actually the EPL and is presented as follows:

\[ E^*_i(\pi) = \frac{r_o V^*(\pi)}{2} \ln(V^*(\pi)) + \left( \frac{2}{r_o V^*(\pi)} \right)^n \]

H10

Where \( E^*_i(\pi) \) and \( V^*(\pi) \) denote optimum levels of expected gross margin and business risk of the portfolio of crops chosen by Farmer \( i \). Because this function is not linear, it is not easy to show that this equation represents a negative relationship between the expected gross margin and business risk of the portfolios of crops chosen by farmers having the same coefficient of absolute risk aversion. However, the identification of the slope of this function is facilitated by carrying out a linear approximation using a first order Taylor expansion. This approximation for Expression H10 corresponds to:

\[ E^*_i(\pi) = \left( \frac{2}{r_o} \right)^n + \left( \frac{r_o}{2} - n \left( \frac{2}{r_o} \right)^n \right) (V^*(\pi) - 1) \]

H11

The slope of this linear approximation of the EPL is:

---

20 A Taylor expansion is a mathematical strategy used to approximate non-linear functions with polynomials (Ostaszewski, 1993). Formally, the Taylor expansion for function \( f(x) \) is: \( f(x) = f(c) + f'(c)(x - c)/1! + f''(c)(x - c)^2/2! + \ldots \), where \( f'(c) \) and \( f''(c) \) are the first and second derivate of function \( f(c) \) evaluated at point \( c \), and the number \( n! \) means the factorial of number \( n \) (i.e. \( 1*2*3*\ldots*n-1*n \)). A first order Taylor expansion corresponds to a Taylor expansion that only considers the first derivative. That is, \( f(x) = f(c) + f'(c)(x - c) \).
By rearranging terms, it is concluded that this slope is negative when:

\[
\left( \frac{r_a}{2} - n \left( \frac{2}{r_a} \right)^n \right) > \frac{1}{n}
\]

This condition is the one that is needed to have an EPL with negative slope consistent with the prediction of the MEFT. Some researchers have found that the coefficient of absolute risk aversion of risk averse farmers is smaller than one (see for example Hardaker et al., 1997; and Hardaker et al., 2004). This empirical evidence suggests, therefore, that this inequality holds.

It is important to stress the fact that the EPL only arises when its slope is not affected by changes in the coefficient of absolute risk aversion. That is, when farmers have the same attitudes towards risk. This is because this coefficient is part of this slope as shown in Expression H12. This is why this assumption was considered by the MEPL proposed in this thesis.

**H.4 An Application**

This appendix ends by deriving graphically the EPL in the example presented in Figure H1. For simplicity, assume that farmers have a coefficient of absolute risk aversion equal to one (i.e. \( r_a = 1 \) for Farmer 1, 2, 3 and 4). The level of business risk chosen by these farmers when facing the efficient frontiers depicted in Figure H1 is obtained from
Equation H8. That is, for each value of $\theta_i$ it is possible to obtain an optimum value of $V(\pi)$ referred to as $V^*(\pi)$. This value of business risk, in turn, can be used to obtain the associated level of expected gross margin by computing $V^*(\pi)$ in the $EPL$ presented in Expression H10. This information is summarised in Table H2.

Table H2. Optimal decision of Farmers 1, 2, 3 and 4.

<table>
<thead>
<tr>
<th>Farmer</th>
<th>Value of $\theta_i$</th>
<th>$V^*(\pi)$</th>
<th>$E^*_i(\pi)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>10.0</td>
<td>3.3</td>
</tr>
<tr>
<td>2</td>
<td>1.5</td>
<td>6.7</td>
<td>3.5</td>
</tr>
<tr>
<td>3</td>
<td>2.0</td>
<td>5.0</td>
<td>4.8</td>
</tr>
<tr>
<td>4</td>
<td>2.5</td>
<td>4.0</td>
<td>6.8</td>
</tr>
</tbody>
</table>

These optimum levels of $E^*_i(\pi)$ and $V^*(\pi)$ are shown in Figure H4:
As predicted by the MEFT, farmers 1, 2, 3 and 4 maximise their expected utility in their individual efficient frontiers at points \(a\), \(b\), \(c\), and \(d\), respectively. The line that joins these optimal points is the EPL presented in Equation H10.

**Appendix I**

**Calculations Developed in the Simulation Presented in Figure 4.4**

The objective of this appendix is to show the calculations that were developed to obtain the EFs in the simulation presented in Figure 4.4. Consider two farmers who produce the same crops: potatoes and wheat. One of the farmers (referred to as ‘the efficient farmer’) does not have any technological restriction and has a land with good quality. The other farmer (referred to as ‘the inefficient farmer’) has either a technological restriction (e.g. old agricultural machinery compared to the efficient farmer) or lower land quality. In order to introduce this effect in the analysis, it was assumed that the
inefficient farmer obtains only 90% of the gross margin obtained by the other farmer. In other words, a factor equal to 0.9 was applied to the historical gross margin of these crops obtained by the efficient farmer. This calculation is presented in the following table, where $GM_{Pot}$ and $GM_{Wheat}$ stand for the expected gross margin (or average of the historical data of past gross margin as defined in Appendix E) of potatoes and wheat, respectively; $V_{Pot}$ and $V_{Wheat}$ are the variances of the historical data of gross margin of potatoes and wheat, respectively, and $COV(Pot; Wheat)$ is the covariance between the historical gross margin of potatoes and wheat.

Table I.1. Gross margin obtained by an efficient and an inefficient farmer.

<table>
<thead>
<tr>
<th>Period of Time</th>
<th>Efficient Farmer</th>
<th>Inefficient Farmer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gross Margin (£/ha)</td>
<td>Gross Margin (£/ha)</td>
</tr>
<tr>
<td></td>
<td>Potatoes</td>
<td>Wheat</td>
</tr>
<tr>
<td>May 2003</td>
<td>1,351</td>
<td>525</td>
</tr>
<tr>
<td>Nov 2003</td>
<td>1,422</td>
<td>566</td>
</tr>
<tr>
<td>May 2004</td>
<td>1,656</td>
<td>598</td>
</tr>
<tr>
<td>Nov 2004</td>
<td>1,652</td>
<td>283</td>
</tr>
<tr>
<td>May 2005</td>
<td>1,732</td>
<td>279</td>
</tr>
<tr>
<td>Nov 2005</td>
<td>1,852</td>
<td>280</td>
</tr>
<tr>
<td>May 2006</td>
<td>1,848</td>
<td>271</td>
</tr>
<tr>
<td>Nov 2006</td>
<td>1,896</td>
<td>337</td>
</tr>
<tr>
<td>May 2007</td>
<td>1,994</td>
<td>361</td>
</tr>
<tr>
<td>Nov 2007</td>
<td>1,854</td>
<td>581</td>
</tr>
<tr>
<td>Average</td>
<td>$GM_{Pot} = 1,726$</td>
<td>$GM_{Wheat} = 408$</td>
</tr>
<tr>
<td>Variance</td>
<td>$V_{Pot} = 43,474$</td>
<td>$V_{Wheat} = 19,944$</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Covariance</td>
<td>COV(Pot;Wheat) = −13,234</td>
<td>COV(Pot;Wheat) = −10,719</td>
</tr>
</tbody>
</table>


Note that the period of time considered in this simulation is from 2003 to 2007. The reason is because this thesis used this interval of time to estimate farmers’ expectations about the future gross margin that they would obtain in 2008. This is because this was the year used to investigate how the ESBF adjusted to the closure of the ASBF. That is, because the crops that they sold in 2008 were actually established in 2007, they had to make expectations about the possible gross margin that they would obtain from these crops in 2008. Associated with this idea, remember that it was assumed in Section 3.3.2.2 and Appendix E that farmers use the average of historical data of past gross margin as an estimator of the gross margin that they will obtain after sowing their crops (in the present simulation, an estimator of the gross margin for 2008). Technically, this means that farmers have adaptive expectations. The example presented in Table I.1 considers a simple average of the historical past gross margin (i.e. the expected gross margin) as an estimator of future the gross margin. However, some more elaborated versions of the adaptive expectations hypothesis consider a weighted average of past gross margins. In these versions higher weights are put in later years with the purpose of capturing the fact that recent realisations of gross margin are more informative (for a discussion, see Dougherty, 2007). One of these more elaborated versions was adopted in the empirical analysis conducted in this thesis. However, the simple average presented in Table I.1 was introduced in this example only for illustrative purposes. The meaning of this simple average is that farmers place the same importance to the historical data of past gross margin.
A shown in Appendix E (see Tables E.1 and E.2), the information presented in Table I.1 can be used to calculate the $EF$s faced by the efficient and the inefficient farmers. Remember that the formulas used to calculate the $EF$ in the example given in Tables E.1 and E.2 in terms of potatoes and wheat are $GM_P = \phi*GM_{Pot} + (1 - \phi)*GM_{Wheat}$ and $V_P = \phi^2*V_{Pot} + (1 - \phi)^2V_{Wheat} + 2*\phi*(1 - \phi)*Cov(Pot;Wheat))$, where $GM_P$ is the expected gross margin of the portfolio formed of potatoes and wheat; $\phi$ and $(1 - \phi)$ are the proportion of land covered by potatoes and wheat, respectively (i.e. they are the proportion of potatoes and wheat used in the portfolio of crops chosen by the farmer); and $V_P$ is the variance of the gross margin of the portfolio of crops. The data obtained from these equations using the information presented in Table I.1 is presented in Table I.2:

<table>
<thead>
<tr>
<th>Weight on Potatoes $\phi$</th>
<th>Weight on Wheat $(1 - \phi)$</th>
<th>Expected Gross Margin of the Portfolio: $GM_P$</th>
<th>Variance of the Portfolio: $V_P$</th>
<th>Expected Gross Margin of the Portfolio: $GM_P$</th>
<th>Variance of the Portfolio: $V_P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0</td>
<td>408</td>
<td>19944</td>
<td>367</td>
<td>16154</td>
</tr>
<tr>
<td>0.1</td>
<td>0.9</td>
<td>540</td>
<td>14207</td>
<td>486</td>
<td>11507</td>
</tr>
<tr>
<td>0.2</td>
<td>0.8</td>
<td>672</td>
<td>10268</td>
<td>604</td>
<td>8317</td>
</tr>
<tr>
<td>0.3</td>
<td>0.7</td>
<td>803</td>
<td>8127</td>
<td>723</td>
<td>6583</td>
</tr>
<tr>
<td>0.4</td>
<td>0.6</td>
<td>935</td>
<td>7783</td>
<td>841</td>
<td>6305</td>
</tr>
<tr>
<td>0.5</td>
<td>0.5</td>
<td>1067</td>
<td>9238</td>
<td>960</td>
<td>7483</td>
</tr>
<tr>
<td>0.6</td>
<td>0.4</td>
<td>1199</td>
<td>12489</td>
<td>1079</td>
<td>10117</td>
</tr>
<tr>
<td>0.7</td>
<td>0.3</td>
<td>1331</td>
<td>17539</td>
<td>1197</td>
<td>14207</td>
</tr>
<tr>
<td>0.8</td>
<td>0.2</td>
<td>1462</td>
<td>24386</td>
<td>1316</td>
<td>19753</td>
</tr>
<tr>
<td>0.9</td>
<td>0.1</td>
<td>1594</td>
<td>33031</td>
<td>1434</td>
<td>26755</td>
</tr>
<tr>
<td>1.0</td>
<td>0.0</td>
<td>1726</td>
<td>43474</td>
<td>1553</td>
<td>35214</td>
</tr>
</tbody>
</table>
The third and fourth columns of this table show the expected value and the variance of the gross margin of the portfolio of crops formed by the efficient farmer. The relationship between these two series of data is actually the $EF$ faced by this farmer. Likewise, the fifth and sixth columns of Table I.2 show the expected value and the variance of the gross margin of the portfolio of crops formed by the inefficient farmer. As in the case of the efficient farmer, the relationship between these two series of data is actually the $EF$ faced by the inefficient farmer. These $EF$s are the efficient frontiers presented in Figure 4.4.

Appendix J

Calculations Developed in the Simulation Presented in Figure 4.5

The objective of this appendix is to show the calculations that were developed to obtain the $EF$s in the simulation presented in Figure 4.5. Consider two farmers: one without market barriers who produces wheat and potatoes; and one who faces a market barrier that prevents him/her from producing potatoes. Because the latter cannot produce potatoes, he/she decided to produce oilseed rape instead. In order to calculate the $EF$ of these two farmers, the same procedure used in the examples presented in Appendices E and I were adopted. The relevant information needed for this calculation is presented in Table J.1:
Table J.1. Gross margin obtained by an efficient and an inefficient farmer.

<table>
<thead>
<tr>
<th>Period of Time</th>
<th>Farmer without market barriers</th>
<th>Farmer with market barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gross Margin (£/ha)</td>
<td>Gross Margin (£/ha)</td>
</tr>
<tr>
<td></td>
<td>Potatoes</td>
<td>Wheat</td>
</tr>
<tr>
<td>May 2003</td>
<td>1,351</td>
<td>525</td>
</tr>
<tr>
<td>Nov 2003</td>
<td>1,422</td>
<td>566</td>
</tr>
<tr>
<td>May 2004</td>
<td>1,656</td>
<td>598</td>
</tr>
<tr>
<td>Nov 2004</td>
<td>1,652</td>
<td>283</td>
</tr>
<tr>
<td>May 2005</td>
<td>1,732</td>
<td>279</td>
</tr>
<tr>
<td>Nov 2005</td>
<td>1,852</td>
<td>280</td>
</tr>
<tr>
<td>May 2006</td>
<td>1,848</td>
<td>271</td>
</tr>
<tr>
<td>Nov 2006</td>
<td>1,896</td>
<td>337</td>
</tr>
<tr>
<td>May 2007</td>
<td>1,994</td>
<td>361</td>
</tr>
<tr>
<td>Nov 2007</td>
<td>1,854</td>
<td>581</td>
</tr>
</tbody>
</table>

Average: GM\textsubscript{Pot} = 1,726, GM\textsubscript{Wheat} = 408
Variance: \text{V}_{\text{Pot}} = 43,474, \text{V}_{\text{Wheat}} = 19,944
Covariance: \text{COV}(\text{Pot};\text{Wheat}) = -13,234, \text{COV}(\text{OSR};\text{Wheat}) = 15,598


As defined in Appendix I, GM\textsubscript{Pot} and GM\textsubscript{Wheat} stand for the expected gross margin of potatoes and wheat, respectively; \text{V}_{\text{Pot}} and \text{V}_{\text{Wheat}} are the variances of the historical data of gross margin of potatoes and wheat, respectively, and \text{COV}(\text{Pot};\text{Wheat}) is the covariance between the historical gross margins of potatoes and wheat. In addition, GM\textsubscript{OSR} represents the expected gross margin of oilseed rape; \text{V}_{\text{OSR}} is the variance of the historical gross margin of oilseed rape; and \text{COV}(\text{OSR};\text{Wheat}) is the covariance between the historical gross margin of oilseed rape and wheat. As in the example presented in Table I.1 in Appendix I (see also the example given in Tables E.1 and E.2 in Appendix E), the equations needed to calculate the EF faced by the farmer without barriers are $GM_P = \phi \times GM_{\text{Pot}} + (1 - \phi) \times GM_{\text{Wheat}}$ and $V_P = \phi^2 \times V_{\text{Pot}} + (1 - \phi)^2 \times V_{\text{Wheat}} + 2 \times \phi (1 - \phi) \times \text{Cov}(\text{Pot};\text{Wheat})$. On the other hand, the equations needed to calculate the
EF of the farmer who is facing market barriers preventing him from producing potatoes are \( \text{GM}_p = \phi \text{GM}_{\text{OSR}} + (1 - \phi) \text{GM}_{\text{Wheat}} \) and \( \text{VP} = \phi^2 \text{V}_{\text{OSR}} + (1 - \phi)^2 \text{V}_{\text{Wheat}} + 2\phi(1 - \phi) \text{Cov(\text{OSR};\text{Wheat}))} \). The data obtained from these equations using the information presented in Table J.1 is presented in the following table:

Table J.2. Efficient frontiers (EFs) faced by the farmers with and without market barriers.

<table>
<thead>
<tr>
<th>Weight on first crop ( \phi )</th>
<th>Weight on second crop ( 1 - \phi )</th>
<th>Expected Gross Margin of the Portfolio: ( \text{GM}_p )</th>
<th>Variance of the Portfolio: ( \text{VP} )</th>
<th>Expected Gross Margin of the Portfolio: ( \text{GM}_p )</th>
<th>Variance of the Portfolio: ( \text{VP} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0</td>
<td>408</td>
<td>19944</td>
<td>367</td>
<td>16154</td>
</tr>
<tr>
<td>0.1</td>
<td>0.9</td>
<td>540</td>
<td>14207</td>
<td>486</td>
<td>11507</td>
</tr>
<tr>
<td>0.2</td>
<td>0.8</td>
<td>672</td>
<td>10268</td>
<td>604</td>
<td>8317</td>
</tr>
<tr>
<td>0.3</td>
<td>0.7</td>
<td>803</td>
<td>8127</td>
<td>723</td>
<td>6583</td>
</tr>
<tr>
<td>0.5</td>
<td>0.6</td>
<td>935</td>
<td>7783</td>
<td>841</td>
<td>6305</td>
</tr>
<tr>
<td>0.6</td>
<td>0.5</td>
<td>1067</td>
<td>9238</td>
<td>960</td>
<td>7483</td>
</tr>
<tr>
<td>0.7</td>
<td>0.4</td>
<td>1199</td>
<td>12489</td>
<td>1079</td>
<td>10117</td>
</tr>
<tr>
<td>0.8</td>
<td>0.3</td>
<td>1331</td>
<td>17539</td>
<td>1197</td>
<td>14207</td>
</tr>
<tr>
<td>0.9</td>
<td>0.2</td>
<td>1462</td>
<td>24386</td>
<td>1316</td>
<td>19753</td>
</tr>
<tr>
<td>1.0</td>
<td>0.1</td>
<td>1594</td>
<td>33031</td>
<td>1434</td>
<td>26755</td>
</tr>
<tr>
<td>0.0</td>
<td>1.0</td>
<td>1726</td>
<td>43474</td>
<td>1553</td>
<td>35214</td>
</tr>
</tbody>
</table>

In this table, the third and fourth columns show the expected value and the variance of the gross margin of the portfolio of crops formed by the farmer who does not face market barriers preventing him/her from producing potatoes. The relationship between these two series of data is actually the EF of by this farmer. Likewise, the fifth and sixth columns of this table show the expected value and the variance of the gross margin of the portfolio of crops formed by the farmer who faces market barriers preventing him/her from producing potatoes. The relationship between these two series of data is the EF faced by this farmer. These EFs are the efficient frontiers plotted in Figure 4.5.
Appendix K

Calculations Developed in the Simulation Presented in Figure 4.14

The objective of this appendix is to show the calculations that were developed to obtain the EFs in the simulation presented in Figure 4.14. Consider the case of a farmer who initially produced wheat and oilseed rape (this portfolio formed of wheat and oilseed rape is referred to as the *original portfolio of crops*). Assume that this farmer faced material resource barriers (but not market barriers) preventing him/her from producing onions. Finally, assume that this individual, in response to the introduction of material resources, replaced oilseed rape with onions (this portfolio formed of wheat and onions is referred to as the *new portfolio of crops*). The information that is needed to calculate
the EFs of the original and the new portfolios of crops is presented in Table K.1, where GM_{Wheat}, GM_{OSR}, and GM_{Onions} stand for the expected gross margin of wheat, oilseed rape and onions, respectively; V_{Wheat}, V_{OSR}, and V_{Onions} and are the variances of the historical data of gross margin of wheat, oilseed rape and onions, respectively; COV(OSR;Wheat) is the covariance between the historical gross margins of oilseed rape and wheat; and COV(Wheat;Onions) is the covariance between the historical gross margins of wheat and onions.

Table K.1. Relevant information to calculate the EFs of the original and new portfolios of crops.

<table>
<thead>
<tr>
<th>Period of Time</th>
<th>Original Portfolio</th>
<th>New Portfolio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wheat</td>
<td>Oilseed Rape</td>
</tr>
<tr>
<td>May 2003</td>
<td>525</td>
<td>441</td>
</tr>
<tr>
<td>Nov 2003</td>
<td>566</td>
<td>469</td>
</tr>
<tr>
<td>May 2004</td>
<td>598</td>
<td>495</td>
</tr>
<tr>
<td>Nov 2004</td>
<td>283</td>
<td>213</td>
</tr>
<tr>
<td>May 2005</td>
<td>279</td>
<td>191</td>
</tr>
<tr>
<td>Nov 2005</td>
<td>280</td>
<td>203</td>
</tr>
<tr>
<td>May 2006</td>
<td>271</td>
<td>220</td>
</tr>
<tr>
<td>Nov 2006</td>
<td>337</td>
<td>250</td>
</tr>
<tr>
<td>May 2007</td>
<td>361</td>
<td>255</td>
</tr>
<tr>
<td>Nov 2007</td>
<td>581</td>
<td>334</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>GM_{Wheat} = 408</td>
<td>GM_{OSR} = 307</td>
</tr>
</tbody>
</table>
Variance

<table>
<thead>
<tr>
<th></th>
<th>( V_{\text{Wheat}} = 19,944 )</th>
<th>( V_{\text{OSR}} = 14,154 )</th>
<th>( V_{\text{Wheat}} = 19,944 )</th>
<th>( V_{\text{Onions}} = 104,128 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariance</td>
<td>( \text{COV(OSR;Wheat)} = 15,598 )</td>
<td>( \text{COV(Wheat;Onions)} = -11,438 )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


As explained in Appendices E, I and J, the equations needed to calculate the \( EF \) of the original portfolio of crops are: 

\[
\text{GM}_P = \phi \text{GM}_{\text{Wheat}} + (1 - \phi) \text{GM}_{\text{OSR}} \quad \text{and} \quad V_P = \phi^2 V_{\text{Wheat}} + (1 - \phi)^2 V_{\text{OSR}} + 2\phi(1 - \phi) \text{COV(Wheat;OSR)}.
\]

Likewise, the equations needed to calculate the \( EF \) of the new portfolio of crops are: 

\[
\text{GM}_P = \phi \text{GM}_{\text{Wheat}} + (1 - \phi) \text{GM}_{\text{Onions}} \quad \text{and} \quad V_P = \phi^2 V_{\text{Wheat}} + (1 - \phi)^2 V_{\text{Onions}} + 2\phi(1 - \phi) \text{COV(Wheat;Onions)}.
\]

The data obtained from these equations using the information presented in Table K.1 is presented in the following tables:

Table K.2. Efficient frontier of the original portfolio of crops.

<table>
<thead>
<tr>
<th>Weight on Wheat ( \phi )</th>
<th>Weight on Oilseed rape ( (1 - \phi) )</th>
<th>Expected Gross Margin of the Portfolio: ( \text{GM}_P )</th>
<th>Variance of the Portfolio: ( V_P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0</td>
<td>307</td>
<td>14,154</td>
</tr>
<tr>
<td>0.1</td>
<td>0.9</td>
<td>317</td>
<td>14,472</td>
</tr>
<tr>
<td>0.2</td>
<td>0.8</td>
<td>327</td>
<td>14,848</td>
</tr>
<tr>
<td>0.3</td>
<td>0.7</td>
<td>337</td>
<td>15,282</td>
</tr>
<tr>
<td>0.4</td>
<td>0.6</td>
<td>347</td>
<td>15,774</td>
</tr>
<tr>
<td>0.5</td>
<td>0.5</td>
<td>358</td>
<td>16,324</td>
</tr>
<tr>
<td>0.6</td>
<td>0.4</td>
<td>368</td>
<td>16,932</td>
</tr>
<tr>
<td>0.7</td>
<td>0.3</td>
<td>378</td>
<td>17,598</td>
</tr>
<tr>
<td>0.8</td>
<td>0.2</td>
<td>388</td>
<td>18,322</td>
</tr>
<tr>
<td>0.9</td>
<td>0.1</td>
<td>398</td>
<td>19,104</td>
</tr>
<tr>
<td>1.0</td>
<td>0.0</td>
<td>408</td>
<td>19,944</td>
</tr>
</tbody>
</table>
Table K.3. Efficient frontier of the new portfolio of crops.

<table>
<thead>
<tr>
<th>Weight on Wheat $\phi$</th>
<th>Weight on Onions $(1 - \phi)$</th>
<th>Expected Gross Margin of the Portfolio: $GM_P$</th>
<th>Variance of the Portfolio: $V_P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>1.0</td>
<td>1,665</td>
<td>104,128</td>
</tr>
<tr>
<td>0.1</td>
<td>0.9</td>
<td>1,539</td>
<td>82,484</td>
</tr>
<tr>
<td>0.2</td>
<td>0.8</td>
<td>1,414</td>
<td>63,780</td>
</tr>
<tr>
<td>0.3</td>
<td>0.7</td>
<td>1,288</td>
<td>48,014</td>
</tr>
<tr>
<td>0.4</td>
<td>0.6</td>
<td>1,162</td>
<td>35,187</td>
</tr>
<tr>
<td>0.5</td>
<td>0.5</td>
<td>1,037</td>
<td>25,299</td>
</tr>
<tr>
<td>0.6</td>
<td>0.4</td>
<td>911</td>
<td>18,350</td>
</tr>
<tr>
<td>0.7</td>
<td>0.3</td>
<td>785</td>
<td>14,340</td>
</tr>
<tr>
<td>0.8</td>
<td>0.2</td>
<td>659</td>
<td>13,269</td>
</tr>
<tr>
<td>0.9</td>
<td>0.1</td>
<td>534</td>
<td>15,137</td>
</tr>
<tr>
<td>1.0</td>
<td>0.0</td>
<td>408</td>
<td>19,944</td>
</tr>
</tbody>
</table>

The third and fourth columns of Table K.2 show the expected value and the variance of the gross margin of the original portfolio of crops formed of wheat and oilseed rape. The relationship between these two series of data is actually the $EF$ of this portfolio of crops. Likewise, the third and fourth columns of Table K.3 show the expected value and the variance of the gross margin of the new portfolio of crops formed of wheat and onions. The relationship between these two series of data is the $EF$ of this portfolio. These $EF$s are the efficient frontiers plotted in Figure 4.14.
Appendix L

Farmers Questionnaire\textsuperscript{21}

SECTION ONE: FARM BUSINESS DETAILS

1. First, could you provide the following information?

a) Date:
b) Name:
c) Age:
d) Sex:
e) Education:
f) Agricultural Training:
g) Number of computers used in the farm:
h) Position:
i) Holding Number:
j) Post Code:
k) County:

\textsuperscript{21} Some limitations of this questionnaire are described in Section 5.3.2.
l) District:
m) Number of acres or hectares with sugar beet before the closure:
__________________________________________________________________

2. Could you tell me how many hectares you occupy?
(1 acre = 0.4047 hectares)

<table>
<thead>
<tr>
<th>Hectares</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>-</td>
</tr>
</tbody>
</table>

Current Breakdown:
Crops: -
Pasture: -

How many of these acres (hectares) do you own?
__________________________________________________________________

3. Do you work full-time (FT) or part-time (PT) on this holding?
   (0) FT  (1) PT

If PT - What other work do you do, if any? Specify
   - Can you say how many other persons work in the farm?

__________________________________________________________________

SECTION TWO: PRODUCTION, MARKET AND FARM INCOME

4. Please, fill the following table for last year (2008).

<table>
<thead>
<tr>
<th>Crop and yield</th>
<th>Total area (Hectares/Acres)</th>
<th>Destination of production (principal retailer)</th>
<th>Quantity destinies (tonnes)</th>
<th>Type of market (contract or free market)</th>
<th>Price (£/tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Which of these crops were used to replace sugar beet?

SECTION THREE: MARKET BARRIERS (B)

5. Which of the following barriers prevented you from choosing other crops with higher levels of gross margin (such as carrots and parsnips for example)? Please, use the scale below to represent your opinion:

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Indifferent</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
</tbody>
</table>

Ba) The markets for these crops are very selective - ( )
Bb) I am not familiar with the productive process of these crops - ( )
Bc) I am not interested in producing other crops with higher gross margin - ( )
Bd) My land is not appropriate to produce these crops - ( )
Be) I don’t have the necessary capital and machinery to produce them - ( )
Bf) Retailers demand quality that it is difficult to achieve - ( )
Bg) Retailers demand a volume that I cannot produce - ( )
Bh) Retailers have too much negotiation power - ( )
Bi) Producing these crops implies collaborative alliances that are difficult to form - ( )
Bj) I am not able to innovate to the extent required to enter the market - ( )
Bk) I don’t have the productive efficiency to the extent required to enter the market - ( )

SECTION FOUR: FARMERS’ GOALS (G)

6. Please, use the scale below to indicate the alternative that best represent your goals associated with farming.

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Indifferent</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
</tbody>
</table>

Ga) Achieve an income as high as possible - ( )
Gb) Enjoy my work - ( )
Gc) Provide for next generations - ( )
Gd) Have sufficient time for leisure - ( )
Ge) Maintain nature and environmental value - ( )
Gf) Produce a good and safe product - ( )
Gg) Gaining recognition and prestige as a farmer - ( )
Gh) Belonging to the farming community - ( )
Gi) Maintaining the family tradition - ( )
Gj) Working with other members of the family - ( )
Gk) Feeling pride of ownership - ( )
Gl) Enjoyment of work tasks - ( )
Gm) Preference for a healthy, outdoor, farming life - ( )
Gn) I enjoy having a purpose and value hard work - ( )
Go) Have independence and freedom from supervision- ( )
Gp) Have the control in a variety of situations - ( )

SECTION FIVE: FARMERS’ ATTITUDES (A), PERCEIVED BEHAVIOURAL CONTROL (P) AND SUBJECTIVE NORMS (N)

7. Please, use the scale below to indicate the alternative that best represent your opinion about the statements listed below.

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Indifferent</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
</tbody>
</table>

Aa) Achieve low debts on my farm - ( )
Ab) My goals and objectives are clear - ( )
Ac) I try to be among the highest producing farms - ( )
Ad) I regularly negotiate with suppliers and buyers - ( )
Ae) I like to try new things on my farm - ( )
Af) Keeping my farm up to date is very important to me - ( )
Ag) In decision-making I take the environment into consideration, even if it lowers gross margin - ( )
Ah) Off-farm income is important for sustaining our farm - ( )
SECTION SIX: BUSINESS STRATEGIES (S)

8. Which of the following business strategies do you think are more suitable to make your farm a successful business enterprise? For your answers, use the following scale

<table>
<thead>
<tr>
<th>Irrelevant (1)</th>
<th>Not very important (2)</th>
<th>Important (3)</th>
<th>Very important (4)</th>
<th>Essential (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sa) Diversification to create added value - ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sb) Diversification to reduce market risk - ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sc) Specialisation in order to be more efficient - ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sd) Specialisation in order to obtain high production - ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Se) Collaborative alliances to increase negotiation power - ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sf) Collaborative alliances to reduce costs - ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sg) Forming social networks in the free market - ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sg) Forming social networks in the contract market - ( )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
9. Please, complete the following table with the information required. Assume that you
don’t have any technical restrictions, and make your choice on the basis that you can
produce only one crop.
To complete this table, use:

(i) Expected gross margin/ hectare: Assign number (10) to the crop with larger gross
margin, and (1) to the crop with the smaller gross margin.

(ii) For Degree of risk, use the following scale:
No risk (1); low risk (2); Risk (3); very risky (4); and extremely risky (5)

(iii) For preferences, rank the crops putting (10) for the most preferred, and (1) for the
least preferred.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Gross margin</th>
<th>Degree of risk</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oilseed Rape</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parsnips</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrots</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strawberries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raspberries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar Beet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10. Now, suppose that you can choose any combination you want of these crops. Assuming
again that you don’t have any restrictions, indicate which combination you
would choose (Please, express you answer in terms of the percentage of land that you
would allocate to each of the crops considered in your choice).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Percentage of land covered by this crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oilseed Rape</td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
</tr>
<tr>
<td>Parsnips</td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td></td>
</tr>
<tr>
<td>Carrots</td>
<td></td>
</tr>
<tr>
<td>Strawberries</td>
<td></td>
</tr>
<tr>
<td>Raspberries</td>
<td></td>
</tr>
<tr>
<td>Sugar Beet</td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>
Appendix M

Letter sent to the British Sugar Corporation

Dear Sir/Madam

My name is Daniel May and I am doing a PhD research at Wolverhampton University, Business School. My work consists of looking for new business alternatives for the ex-sugar beet growers of the West Midlands. This project involves a survey that will be carried out in order to

Please see Section 5.3.3 for a discussion about the poor response obtained to this letter.
investigate the economic motivations of these farmers. Unfortunately we do not have the list of
the ex-sugar beet farmers of this area. It is for this reason that I would be grateful if you could
help me with my research by providing me a list of the farmers that used to sell sugar beet to
Allscott before the closure of this factory. Of course, we will be more than willing to provide you
the results that we obtain from this research.

Yours faithfully,

Daniel May
Research Student
Wolverhampton University
Business School
Compton Road West
WV3 9DX

Appendix N

Letter sent to the farmers of the West Midlands by means of the NFU newsletter

Dear Sir

Assistant to Former Sugar Beet Growers

I am writing to let you know of a project underway to assist former growers of sugar
beet in the West Midlands in assessing the prospects of future farm enterprise choices.

The University of Wolverhampton Business School have secured funding from the
Oldacre Foundation to review how the loss of the sugar beet crop in the West Midlands
was handled in 2006 and to explore the lessons that should have been learnt from this.
We then have a remit from the Foundation to raise awareness amongst farmers of these
lessons for the future benefit of the industry.

23 Please see Section 5.3.3 for a discussion about the poor response obtained to this letter.
Should you have any questions regarding this project, the project leader is Dr Graham Tate and he can be contacted by phone on 01902 323978 or by email on graham.tate@wlv.ac.uk.

It would really help our research if you would agree to collaborate with us by way of a short interview to discuss how you approached the loss of the sugar crop and your farm business. If you would not mind completing the attached return slip one of our research team will get in touch with you to arrange a discussion.

Thank you in advance for your important collaboration.

Yours faithfully,

Daniel May

-------------------------------------------------------------------------------------------------------
From: --------------------------------------------- To: Daniel May
----------------------------------------------------- UWBS Priorslee Campus
----------------------------------------------------- Telford, Shropshire
----------------------------------------------------- TF2 9NT

Appendix O

Detailed Explanation of how the Variance of the Portfolio of Crops is Calculated Based on a Practical Example

The objective of this appendix is to explain in detailed the method adopted in this thesis to calculate the variance of the portfolio of crops. For this purpose, a practical example is considered. This method was already considered in the examples introduced in Appendices E, I, J and K.

Suppose that a determined farmer referred to as farmer \( k \) chooses a portfolio of crops formed of crops A and B. In order to calculate the variance of the gross margin of this
portfolio, consider the information presented in Table O.1 (this information is fictitious):

<table>
<thead>
<tr>
<th>Year</th>
<th>Gross Margin Crop A (£/ha)</th>
<th>Gross Margin Crop B (£/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>100</td>
<td>95</td>
</tr>
<tr>
<td>2007</td>
<td>115</td>
<td>98</td>
</tr>
<tr>
<td>2008</td>
<td>90</td>
<td>85</td>
</tr>
<tr>
<td>2009</td>
<td>98</td>
<td>100</td>
</tr>
<tr>
<td>2010</td>
<td>120</td>
<td>105</td>
</tr>
<tr>
<td>2011</td>
<td>125</td>
<td>90</td>
</tr>
</tbody>
</table>

Before calculating the variance of the gross margin of this portfolio of crops, it is necessary to calculate the variance of the gross margin of each crop and the covariance of the gross margin of these crops. The formulas for these variances and covariance are (see Upton and Cook, 1996):

\[ V(\pi_A) = \frac{\sum_{j=2006}^{2011} (\pi_{Aj} - \bar{\pi}_A)^2}{n - 1} \]  \hspace{1cm} (O.1)

\[ V(\pi_B) = \frac{\sum_{j=2006}^{2011} (\pi_{Bj} - \bar{\pi}_B)^2}{n - 1} \]  \hspace{1cm} (O.2)

\[ COV(\pi_A; \pi_B) = \frac{\sum_{j=2006}^{2011} (\pi_{Aj} - \bar{\pi}_A)(\pi_{Bj} - \bar{\pi}_B)}{n - 1} \]  \hspace{1cm} (O.3)
Where $\pi_A$ and $\pi_B$ denote gross margin of crops A and B, respectively; $V(\pi_A)$ and $V(\pi_B)$ are the variances of the gross margin of crops A and B, respectively; $\pi_{Aj}$ and $\pi_{Bj}$ are the gross margin of crops A and B in year $j$; $\overline{\pi}_A$ and $\overline{\pi}_B$ are the averages of the gross margin of crops A and B, respectively, calculated over the referential period of time; $n$ is the number of years (or number of semesters if the data is presented in semesters) considered in the referential period of time; and $COV(\pi_A; \pi_B)$ is the covariance between the gross margin of crops A and B.

As shown in Equations O.1, O.2 and O.3, the averages of the gross margin of crops A and B (i.e. $\overline{\pi}_A$ and $\overline{\pi}_B$) are needed to calculate the variances and covariance. Using the information presented in Table O.1, these averages are (see Upton and Cook, 1996):

$$\overline{\pi}_A = \frac{\sum_{j=2006}^{2011} \pi_{Aj}}{n} = \frac{100 + 115 + 90 + 98 + 120 + 125}{6} = 108$$  \hspace{1cm} (O.4)

$$\overline{\pi}_B = \frac{\sum_{j=2006}^{2011} \pi_{Bj}}{n} = \frac{95 + 98 + 85 + 100 + 105 + 90}{6} = 96$$  \hspace{1cm} (O.5)

Using these averages and the information presented in Table O.1, the variances and covariance described in Equations O.1, O.2 and O.3 are calculated as follows:
\[
V(\pi_A) = \frac{\sum_{j=2006}^{n=2011} (\pi_{Aj} - \bar{\pi}_A)^2}{n - 1} = \\
= \frac{(100 - 108)^2 + (115 - 108)^2 + (90 - 108)^2 + (98 - 108)^2 + (120 - 108)^2 + (125 - 108)^2}{5} = 194
\]

(O.6)

\[
V(\pi_B) = \frac{\sum_{j=2006}^{n=2011} (\pi_{Bj} - \bar{\pi}_B)^2}{n - 1} = \\
= \frac{(95 - 96)^2 + (98 - 96)^2 + (85 - 96)^2 + (100 - 96)^2 + (105 - 96)^2 + (90 - 96)^2}{5} = 52
\]

(O.7)

\[
\text{COV}(\pi_A; \pi_B) = \frac{\sum_{j=2006}^{n=2011} (\pi_{Aj} - \bar{\pi}_A)(\pi_{Bj} - \bar{\pi}_B)}{n - 1} = \\
\]

(O.8)
Having calculated the variances of the gross margin of crops A and B and the associated covariance, it is now possible to calculate the variance of the portfolio of crops chosen by farmer \( k \) using the following equation:

\[
V(\pi_k) = w_A^2V(\pi_A) + w_B^2V(\pi_B) + 2w_Aw_B\text{COV}(\pi_A;\pi_B)
\] (O.9)

Where \( w_A \) is the proportion of land occupied by crop A, and \( w_B \) is the proportion of land occupied by crop B. Because the farmer only produces these crops, it holds that \( w_A + w_B = 1 \). Let us assume that farmer \( k \) decided to cover 70% of the land with crop A (i.e. \( w_A = 0.7 \)) and 30% with crop B (i.e. \( w_B = 0.3 \)). With this information and also using the results obtained in Expressions O.6, O.7 and O.8, the variance of the portfolio of crops is calculated as follows:

\[
V(\pi_k) = w_A^2V(\pi_A) + w_B^2V(\pi_B) + 2w_Aw_B\text{COV}(\pi_A;\pi_B)
\] (O.10)

\[
= 0.7^2*194 + 0.3^2*52 + 2*0.7*0.3*37 = 115
\]

Therefore, in this example the variance of the portfolio of crops chosen by farmer \( k \) is equal to £115/ha².
Appendix P

Proving that an ordinal utility can be rescaled without affecting its meaning in terms of individuals’ preferences.

Suppose that an individual prefers option A to B. From an ordinal point of view (see Eaton et al., 1999), this can be represented by assigning an arbitrary value equal to 10 to option A and 2 to option B. But the same preference can be described by rescaling these values as $\lambda \times 10 + \gamma$ for option A and $\lambda \times 2 + \gamma$ for option B for any $\lambda > 0$ and any $\gamma \in \mathbb{R}$ (i.e. any real number). For instance, if $\lambda = 5$ and $\gamma = 2$, then the rescaled value of the utility for option A is $5 \times 10 + 2 = 52$; and the rescaled value of the utility of B is $5 \times 2 + 2 = 12$. In this case it also holds that the utility of option A is higher than the utility of option B meaning that A is preferred to B.

On the other hand, when the preferences of individuals satisfy some specific assumptions, they not only can be assigned a utility value as discussed in the last paragraph, but also a functional form or utility function representing these preferences (Beardon et al., 2002). These assumptions are: (i) preferences are complete meaning that individuals know their preferences over all available options; (ii) preferences are transitive in the sense that if an individual prefers A to B, and B to C, then this individual prefers A to C; and (iii) individuals prefer more than less which is referred to as the assumption of non-satiation (Eaton et al., 1999; and Morgan et al., 2006).
Researchers have proposed a number of ordinal utility functions to represent preferences under these assumptions. Any of these utility functions can be used to represent individuals’ preferences. However, comparison between individuals requires the adoption of a similar ordinal utility function that uses the same scale.

The present investigation adopted a particular utility (ordinal) function referred to as the exponential utility function which corresponds to (see Appendix F):

\[ U(\pi) = 1 - e^{-r_a \pi} \]  

(P.1)

Where \( r_a \) is the coefficient of absolute risk aversion (this coefficient is formally defined in Section 3.3.2.1 and Appendix D). As explained in Appendix F, the reason of why this function is related to the EV approach is because the expected value of the second order Taylor expansion of this function is the equation 5.3 presented in Chapter Five which has as arguments the variables considered by this approach\(^{24}\): expected gross margin \( E(\pi) \); and variance of gross margin \( V(\pi) \).

Let us now explain how the concept of ordinal utility provides a useful way to obtain a proxy for the expected utility of the ESBF that is needed in the experimental method designed to test the HRA and the HSCRA (see Part b of Section 5.3.4.3). This proxy is derived from the second order Taylor expansion of Equation P.1 (see Footnote 24):

\(^{24}\) A Taylor expansion is a mathematical strategy used to approximate non-linear functions with polynomials (Ostaszewski, 1993). Formally, the Taylor expansion for function \( f(x) \) is: \( f(x) = f(c) + f'(c)(x - c)/1! + f''(c)(x - c)^2/2! + ... \), where \( f'(c) \) and \( f''(c) \) are the first and second derivative of function \( f(c) \) evaluated at point \( c \), and the number \( n! \) means the factorial of number \( n \) (i.e. \( 1*2*3*...*n-1*n \)). A first second order Taylor expansion corresponds to a Taylor expansion that only considers the first and second derivatives. That is, \( f(x) = f(c) + f'(c)(x - c) + f''(c)(x - c)^2/2 \).
\[
U(\pi) = U(0) + U'(0)\pi + \frac{1}{2} U''(0)\pi^2
\]  
(P.2)

Where \(U(0)\) is the utility function presented in Expression P.1 evaluated at \(\pi = 0\); \(U'(0)\) is the first derivative of the utility function presented in Expression P.1 evaluated at \(\pi = 0\); and \(U''(0)\) is the second derivative of the utility function presented in Expression P.1 evaluated at \(\pi = 0\). From Equation P.2,

\[
U(0) = 0 \quad \text{(P.3)}
\]

\[
U'(0) = r_a \quad \text{(P.4)}
\]

\[
U''(0) = -r_a^2 \quad \text{(P.5)}
\]

By putting Equations P.3, P.4 and P.5 into P.2, the second order Taylor expansion of Equation P.1 becomes:

\[
U(\pi) = r_a \pi - \frac{r_a^2}{2} \pi^2 \quad \text{(P.6)}
\]

Adding and subtracting \(E(\pi)\) to the variable \(\pi\) presented in the second term of the right side of this equation, this expression can be represented as:
\[ U(\pi) = r_o \pi - \frac{r_o^2}{2}(\pi - E(\pi))^2 \]
\[ = r_o \pi - \frac{r_o^2}{2}(\pi - E(\pi))^2 - r_o(\pi - E(\pi))E(\pi) - \frac{r_o^2}{2}E(\pi)^2 \]  

(P.7)

Where, as defined above, \( E(\pi) \) denotes expected gross margin. It is important to remember two facts associated with this expression. Firstly, this equation is an approximation of the utility function presented in Expression P.1. This means that this function represents the same. Secondly, because Equations P.1 and P.7 represents the same, they both correspond to an ordinal utility function. This implies that they both represent an ordering of preferences over levels of gross margin. As a consequence, they can be rescaled without losing the property of representing preferences as discussed above. Let’s make the first rescaling of Expression P.7 by dividing both sides by \( r_o \neq 0 \):

\[ \overline{U}(\pi) \equiv \frac{U(\pi)}{r_o} = \pi - \frac{r_o}{2}(\pi - E(\pi))^2 - r_o(\pi - E(\pi))E(\pi) - \frac{r_o}{2}E(\pi)^2 \]  

(P.8)

Where \( \overline{U}(\pi) \) is the rescaled utility function. Let as now make the second rescaling by adding in both sides the term \( \frac{r_o}{2}E(\pi)^2 \):

\[ \overline{U}(\pi) = \pi - \frac{r_o}{2}(\pi - E(\pi))^2 - r_o(\pi - E(\pi))E(\pi) \]  

(P.9)
Where \( \overline{U}(\pi) = \overline{U}(\pi) + \frac{r_a}{2} E(\pi)^2 \). Note that this rescale is meaningful because the utility maintains the property of representing preferences. That is, if \( \pi > \pi' \), then \( \pi \) is preferred to \( \pi' \) under the non-satiation assumption of preferences described above. This preference is captured by the second rescaled utility function because \( \overline{U}(\pi) + \frac{r_a}{2} E(\pi)^2 > \overline{U}(\pi') + \frac{r_a}{2} E(\pi')^2 \) for all \( \pi > \pi' \) which implies that \( \overline{U}(\pi) > \overline{U}(\pi') \) for all \( \pi > \pi' \).

Let us now apply the expectation operator (i.e. \( E \)) in both sizes of Equation P.9. By applying this operator and by using algebra of expectation (see Upton and Cook, 1996, p. 192), the Equation P.9 becomes:

\[
E\left( \overline{U}(\pi) \right) = E(\pi) - \frac{r_a}{2} E(\pi - E(\pi))^2 \quad \text{(P.10)}
\]

Note that the last term \( r_a \) \( (\pi - E(\pi))E(\pi) \) disappeared because the expected value of this term is \( r_a (E(\pi) - E(\pi))E(\pi) = 0 \). Finally, because for definition the term \( E(\pi - E(\pi))^2 \) corresponds to the variance of the gross margin (Upton and Cook, 1996), that is, \( E(\pi - E(\pi))^2 = V(\pi) \), this expression becomes:

\[
E\left( \overline{U}(\pi) \right) = E(\pi) - \frac{r_a}{2} V(\pi) \quad \text{(P.11)}
\]

There is an important fact associated with this expression. That is, this is the same equation than the one presented in Equation 5.3 in Chapter Five. This implies that
without losing the ordinal meaning of the utility function (i.e. an ordering of preferences over levels of expected gross margin) it was possible to transform the original utility function presented in Equation P.1 into this version which is consisting with the EV approach. This is because Equation P.1 links the expected gross margin \( E(\pi) \) with the variance of gross margin \( V(\pi) \) which is in essence the variables considered by this approach (see Sections 3.3.2.2). Therefore, the expected utility derived from the second order Taylor expansion is consistent with the notion of ordinal utility.

Let us now transform Equation P.11 into an econometric version in order to justify the proxy of expected utility adopted in the experimental method. First of all, let us rescale this equation by multiplying both sided by a constant \( \beta_1 > 0 \) as follows:

\[
E(\tilde{U}(\pi)) = E(\beta_1 \bar{U}(\pi)) = \beta_1 E(\pi) - \beta_1 \frac{\mu}{2} V(\pi)
\]  

(P.12)

This rescaling still maintains the ordinal property of the utility because the expected utility increases as the expected gross margin increases. Finally, let \( -\beta_1 r_\sigma/2 = \beta_2 \) and let us rescale the utility by adding in both sides the constant \( \beta_0 \). Adopting these changes the Equation P.12 becomes:

\[
E(\tilde{U}(\pi)) = E(\tilde{U}(\pi)) + \beta_0 = \beta_0 + \beta_1 E(\pi) + \beta_2 V(\pi)
\]  

(P.13)

Again, because this rescaling does not affects the ordinarily property of the utility function, the variable \( E(\tilde{U}(\pi)) \) (i.e. the resulting expected utility function after the rescaling) is meaningful because it describes preferences. This is actually the econometric model presented in Equation 5.5 in Chapter Five. Now, because utility
numbers in an ordinal utility reveal only the relative ordering of preferred options and nothing about the distance between different options in terms of desirability (Eaton et al., 1999), it is concluded that any arbitrary scale used to represent preferences can be adopted in the formulation presented in Equation P.13. Obviously different scales would be captured as different coefficients when estimating this model using linear regression. However, the meaning of the utility would be the same independently of the scale. That is, it reflects an ordering of preferred options.
## Appendix Q

**Prices, intermediaries and uses of the crops adopted by the ESBF in 2008**

Table Q.1 Prices (£/tonne) obtained by the ESBF in the free and contract market in 2008

<table>
<thead>
<tr>
<th>Crop</th>
<th>Free Market</th>
<th>Contract</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>max</td>
</tr>
<tr>
<td>Wheat</td>
<td>113.5</td>
<td>155.0</td>
</tr>
<tr>
<td>Barley</td>
<td>114.9</td>
<td>155.0</td>
</tr>
<tr>
<td>Oilseed Rape</td>
<td>287.5</td>
<td>320.0</td>
</tr>
<tr>
<td>Oats</td>
<td>93.5</td>
<td>95.0</td>
</tr>
<tr>
<td>Potatoes</td>
<td>112.0</td>
<td>152.5</td>
</tr>
<tr>
<td>Sugar Beer</td>
<td>24.2</td>
<td>30.0</td>
</tr>
<tr>
<td>Fodder Beet</td>
<td>19.2</td>
<td>24.0</td>
</tr>
<tr>
<td>Maize</td>
<td>135.0</td>
<td>135.0</td>
</tr>
<tr>
<td>Beans</td>
<td>122.5</td>
<td>125.0</td>
</tr>
<tr>
<td>Peas</td>
<td>280.0</td>
<td>280.0</td>
</tr>
<tr>
<td>Rye</td>
<td>92.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Carrots</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Herb Seed</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Triticale</td>
<td>118.0</td>
<td>118.0</td>
</tr>
<tr>
<td>Turnips</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Borage</td>
<td>-----</td>
<td>-----</td>
</tr>
</tbody>
</table>
### Figure Q.2 Intermediaries and production for the crops chosen by the ESBF in 2008

<table>
<thead>
<tr>
<th>Crop</th>
<th>Intermediaries</th>
<th>Types of production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>Frontier, Sun Valley, Glencom, Wrekin Grain, Shropshire Grain, Robin Appel, G.O. Davis, Criddle, and different merchants that bought wheat in open fields.</td>
<td>Malting, milling, animal feed, grains seeds, and bread making</td>
</tr>
<tr>
<td>Barley</td>
<td>Frontier, Wrekin Grain, G.O. Davis, Robin Appel, Monsanto Vistive, Glencom and different merchants that bought wheat in open fields.</td>
<td>Malting, milling, animal feed, grains and seeds</td>
</tr>
<tr>
<td>Oilseed rape</td>
<td>United Oilseed, Frontier, Criddle, Liverpool Crusher, G.O. Davis, Masstock, Coors Brewery, Bass, Criddle, Malster, Syngenta, Trevor Cope, Wynnstay and different merchants that bought wheat in open fields.</td>
<td>Crushing for oil and food</td>
</tr>
<tr>
<td>Oats</td>
<td>Frontier, Wrekin Grain, G.O. Davis, Morning Food, Manchester Breakfast Cereals and Trevor Cope</td>
<td>Human consumption and seeds</td>
</tr>
<tr>
<td>Potatoes</td>
<td>McCain, Green Vale, Higgins, Chips Shops, and different merchants.</td>
<td>Seeds, salads and the production of chips</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>Local farmers and the British Sugar</td>
<td>Animal feed, stock feed and production of sugar</td>
</tr>
<tr>
<td>Fodder beet</td>
<td>Local farmers</td>
<td>Animal feed and Stock feed</td>
</tr>
<tr>
<td>Maize</td>
<td>Country Wide, Whites, local farmers and local dairy farmers</td>
<td>Animal feed, silage and seeds</td>
</tr>
<tr>
<td>Beans</td>
<td>Frontier, Robin Appel, and Middle Man</td>
<td>Human consumption and animal feed</td>
</tr>
<tr>
<td>Peas</td>
<td>United Oilseed and Glencom</td>
<td>Production of oil and feed</td>
</tr>
<tr>
<td>Rye</td>
<td>Rybita</td>
<td>Human and animal feed</td>
</tr>
<tr>
<td>Carrots</td>
<td>Farm shop retailer and Freshagro</td>
<td>Human consumption</td>
</tr>
<tr>
<td>Onions</td>
<td>Farm shop retailer and Middle Man</td>
<td>Human consumption</td>
</tr>
<tr>
<td>Herb seeds</td>
<td>Limagrain and British Seed Haster</td>
<td>Not available</td>
</tr>
<tr>
<td>Triticale</td>
<td>Local farmer</td>
<td>Livestock feed</td>
</tr>
<tr>
<td>Parsnips</td>
<td>Farm shop</td>
<td>Human consumption</td>
</tr>
<tr>
<td>Strawberries</td>
<td>Farm shop</td>
<td>Human consumption</td>
</tr>
</tbody>
</table>
### Appendix R

#### Extended Version of the Regression Model Presented in Table 6.7

Table R.1: Regression results including dummy variables for most of the farmers in the sample. Some observations were omitted to avoid the problem of perfect multicolineality (see Dougherty, 2007).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient (n = 48)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>16.73* (-27.43)</td>
</tr>
<tr>
<td>Business Risk (in natural logarithm)</td>
<td>-1.14* (-17.46)</td>
</tr>
<tr>
<td>Dummy variable for observation 3</td>
<td>-0.34 (-4.96)</td>
</tr>
<tr>
<td>Dummy variable for observation 4</td>
<td>-0.05 (-1.27)</td>
</tr>
<tr>
<td>Dummy variable for observation 5</td>
<td>-0.12 (-4.05)</td>
</tr>
<tr>
<td>Dummy variable for observation 6</td>
<td>0.08 (1.77)</td>
</tr>
<tr>
<td>Dummy variable for observation 7</td>
<td>-0.19 (-4.06)</td>
</tr>
<tr>
<td>Dummy variable for observation 8</td>
<td>2.57* (26.35)</td>
</tr>
<tr>
<td>Dummy variable for observation 9</td>
<td>-0.07 (-1.58)</td>
</tr>
<tr>
<td>Dummy variable for observation 10</td>
<td>-0.13 (-4.33)</td>
</tr>
<tr>
<td>Dummy variable for observation 11</td>
<td>-0.12 (-4.00)</td>
</tr>
<tr>
<td>Dummy variable for observation 12</td>
<td>-0.18 (-5.87)</td>
</tr>
<tr>
<td>Dummy variable for observation 13</td>
<td>-0.16 (-5.24)</td>
</tr>
<tr>
<td>Dummy variable for observation 14</td>
<td>0.01 (0.21)</td>
</tr>
<tr>
<td>Dummy variable for observation 15</td>
<td>0.04 (1.32)</td>
</tr>
<tr>
<td>Dummy variable for observation 16</td>
<td>0.06 (1.94)</td>
</tr>
<tr>
<td>Dummy variable for observation 17</td>
<td>0.03 (0.94)</td>
</tr>
<tr>
<td>Dummy variable for observation 18</td>
<td>-0.36 (-7.53)</td>
</tr>
<tr>
<td>Dummy variable for observation 19</td>
<td>0.03 (0.81)</td>
</tr>
<tr>
<td>Dummy variable for observation 20</td>
<td>0.05 (1.57)</td>
</tr>
<tr>
<td>Dummy variable for observation 21</td>
<td>0.22 (5.83)</td>
</tr>
<tr>
<td>Dummy variable for observation 22</td>
<td>0.32 (7.98)</td>
</tr>
<tr>
<td>Dummy variable for observation 23</td>
<td>0.14 (3.94)</td>
</tr>
<tr>
<td>Dummy variable for observation 24</td>
<td>0.07 (2.17)</td>
</tr>
<tr>
<td>Dummy variable for observation 25</td>
<td>0.16 (4.44)</td>
</tr>
<tr>
<td>Dummy variable for observation 26</td>
<td>0.03 (1.04)</td>
</tr>
<tr>
<td>Dummy variable for observation 27</td>
<td>0.01 (0.40)</td>
</tr>
<tr>
<td>Dummy variable for observation 28</td>
<td>0.09 (2.57)</td>
</tr>
<tr>
<td>Dummy variable for observation 29</td>
<td>0.01 (0.42)</td>
</tr>
<tr>
<td>Dummy variable for observation 30</td>
<td>-0.13 (-4.33)</td>
</tr>
<tr>
<td>Dummy variable for observation 31</td>
<td>0.03 (0.88)</td>
</tr>
<tr>
<td>Dummy variable for observation 32</td>
<td>1.67* (31.77)</td>
</tr>
<tr>
<td>Dummy variable for observation 33</td>
<td>-0.12 (-3.01)</td>
</tr>
<tr>
<td>Dummy variable for observation 34</td>
<td>0.14 (3.81)</td>
</tr>
<tr>
<td>Dummy variable for observation 35</td>
<td>0.13 (4.54)</td>
</tr>
<tr>
<td>Dummy variable for observation 36</td>
<td>-0.58* (-13.64)</td>
</tr>
<tr>
<td>Dummy variable for observation 37</td>
<td>0.33 (8.15)</td>
</tr>
<tr>
<td>Dummy variable for observation 38</td>
<td>-0.23 (-8.08)</td>
</tr>
<tr>
<td>Dummy variable for observation 39</td>
<td>0.02 (0.53)</td>
</tr>
<tr>
<td>Dummy variable for observation 40</td>
<td>-0.02 (-0.67)</td>
</tr>
<tr>
<td>Dummy variable for observation 41</td>
<td>0.07 (2.13)</td>
</tr>
<tr>
<td>Dummy variable for observation 42</td>
<td>0.16 (4.58)</td>
</tr>
<tr>
<td>Dummy variable for observation 43</td>
<td>0.31 (7.62)</td>
</tr>
<tr>
<td>Dummy variable for observation 44</td>
<td>-0.06 (-1.98)</td>
</tr>
<tr>
<td>Dummy variable for observation 45</td>
<td>-0.08 (-2.75)</td>
</tr>
<tr>
<td>Dummy variable for observation 46</td>
<td></td>
</tr>
</tbody>
</table>
According to this regression, the only dummy variables that were significant are the
dummies for observations 8, 32 and 37. This result implies that these observations are
outliers a fact that can also be identified in Figure 6.6 in Section 6.4.4. This is why these
observations were eliminated from the regression presented in Table 6.7.
Appendix S

Calculations Developed to Obtain the Information Presented in Table 7.2

The objective of this Appendix is to explain how the information presented in Table 7.2 was calculated. This information was obtained from the individuals who became outliers after the removal of the material resource barriers. That is, the observations 1, 3, 6, 24, 25, 27, 42, 45 and 46. Note that the outliers corresponding to observations 8 and 37 were omitted because they were also outliers before the shock. As a consequence, they did not become outliers after the removal of material resource barriers because they already were outliers. The information of expected gross margin of the portfolio of crops chosen by observations 1, 3, 6, 24, 25, 27, 42, 45 and 46 is presented in Table S.1:

Table S.1. Expected gross margin of the portfolio of crops chosen by the farmers who became outliers.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Expected Gross Margin of the Portfolio Before the Shock (£/ha)</th>
<th>Expected Gross Margin of the Portfolio after the Shock (£/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>430</td>
<td>1,754</td>
</tr>
<tr>
<td>3</td>
<td>935</td>
<td>2,041</td>
</tr>
<tr>
<td>6</td>
<td>911</td>
<td>1,942</td>
</tr>
<tr>
<td>24</td>
<td>354</td>
<td>2,608</td>
</tr>
<tr>
<td>25</td>
<td>351</td>
<td>1,878</td>
</tr>
<tr>
<td>27</td>
<td>333</td>
<td>1,361</td>
</tr>
<tr>
<td>42</td>
<td>620</td>
<td>2,265</td>
</tr>
<tr>
<td>45</td>
<td>355</td>
<td>2,312</td>
</tr>
<tr>
<td>46</td>
<td>349</td>
<td>4,412</td>
</tr>
</tbody>
</table>
The averages of the gross margin achieved by the portfolio of crops chosen by these farmers before \((GM_B)\) and after \((GM_A)\) the shock were calculated using the following formulas:

\[
GM_B = \frac{\sum_{i}^n E(\pi_{Bi})}{n}
\]  

\[
GM_A = \frac{\sum_{i}^n E(\pi_{Ai})}{n}
\]

(S.1)  

(S.2)

Where \(E(\pi_{Bi})\) and \(E(\pi_{Ai})\) are the expected gross margins of the portfolios of crops chosen by farmer \(i\) before and after the shock, respectively; and \(n\) is the number of observations included in the calculation. The variances of the gross margin of the portfolios of crops chosen by the outliers before \((VGM_B)\) and after \((VGM_A)\) incidence of the shock were calculated using the following definitions:

\[
VGM_B = \frac{\sum_{i=1}^{n} (\pi_{Bi} - GM_B)^2}{n - 1}
\]

\[
VGM_A = \frac{\sum_{i=1}^{n} (\pi_{Ai} - GM_A)^2}{n - 1}
\]

(S.3)  

(S.4)
Using these equations, the following calculations were carried out:

\[
GM_b = \frac{430 + 935 + 911 + 354 + 351 + 333 + 620 + 355 + 349}{9} = 515 
\]  
(S.5)

\[
GM_A = \frac{1,754 + 2,041 + 1,942 + 2,608 + 1,878 + 1,361 + 2,265 + 2,312 + 4,412}{9} = 2,286 
\]  
(S.6)

\[
VGM_b = \frac{(430 - 515)^2 + (935 - 515)^2 + (911 - 515)^2 + (354 - 515)^2 + (351 - 515)^2 + (333 - 515)^2 + (620 - 515)^2 + (349 - 515)^2}{8} = 61,251 
\]  
(S.7)

\[
VGM_A = \frac{(1,754 - 2,286)^2 + (2,041 - 2,286)^2 + (1,942 - 2,286)^2 + (2,608 - 2,286)^2 + (1,878 - 2,286)^2 + (1,361 - 2,286)^2 + (2,265 - 2,286)^2 + (2,312 - 2,286)^2 + (4,412 - 2,286)^2}{8} = 763,305 
\]  
(S.8)

These results are the numbers presented in Table 7.2.
Appendix T

Calculations Developed to Obtain the Information Presented in Table 7.3

The objective of this Appendix is to explain how the information presented in Table 7.3 was calculated. For this purpose, consider the information presented in the following Table:

Table T.1. Variances (i.e. business risk) of the Gross Margin of the portfolios of crops chosen by the outlier farmers.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Business Risk of the Portfolio Before the Shock (£²/ha²)</th>
<th>Business Risk of the Portfolio after the Shock (£²/ha²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11,490</td>
<td>126,913</td>
</tr>
<tr>
<td>3</td>
<td>4,379</td>
<td>333,307</td>
</tr>
<tr>
<td>6</td>
<td>6,504</td>
<td>473,330</td>
</tr>
<tr>
<td>24</td>
<td>14,753</td>
<td>479,895</td>
</tr>
<tr>
<td>25</td>
<td>16,105</td>
<td>92,984</td>
</tr>
</tbody>
</table>
As pointed out in Footnotes 1 and 2, a proxy of business risk adopted in this thesis is the variance of the gross margin of the portfolios of crops adopted by the ESBF included in the sample. This is the information presented in Table T.1 for the case of the outlier farmers. The averages of these variances or business risk before (BR$_B$) and after (BR$_A$) the shock were calculated using the following formulas:

$$BR_B = \frac{\sum_{i=1}^{n} V(\pi_{Bi})}{n}$$  \hspace{1cm} (T.1)

$$BR_A = \frac{\sum_{i=1}^{n} V(\pi_{Ai})}{n}$$  \hspace{1cm} (T.2)

Where $V(\pi_{Bi})$ and $V(\pi_{Ai})$ are the variances of the gross margin of the portfolios of crops chosen by farmer $i$ before and after the shock, respectively; and $n$ is the number of observations included in the calculation. The variances of the business risk of the

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>14,812</td>
<td>170,736</td>
</tr>
<tr>
<td>42</td>
<td>9,015</td>
<td>228,545</td>
</tr>
<tr>
<td>45</td>
<td>13,142</td>
<td>392,822</td>
</tr>
<tr>
<td>46</td>
<td>13,064</td>
<td>852,504</td>
</tr>
</tbody>
</table>
portfolios of crops chosen by the outliers before (VBR\(^B\)) and after (VBR\(^A\)) incidence of the shock were calculated using the following definitions:

\[
VBR_B^{n} = \frac{\sum_{i=1}^{n} (V(\pi_{B_i}) - BR_B)^2}{n - 1}
\]  

(T.3)

\[
VBR_A^{n} = \frac{\sum_{i=1}^{n} (V(\pi_{A_i}) - BR_A)^2}{n - 1}
\]  

(T.4)

It is important to highlight the fact that \(V(\pi_{B_i})\) is the variance of the historical data of gross margin of the portfolio adopted by farmer \(i\). That is, this is the indicator of business risk of this portfolio (see Footnotes 1 and 2). In contrast, \(VBR\(^B\)) is the variance of business risk across farmers. That is, this is a measure of dispersion of business risk across farmers and not a measure of dispersion of the historical data of gross margin.

However, they are related as shown in Equations T.3 and T.4.
Using the Equations T.1, T.2, T.3 and T.4, the following calculations were carried out:

\[ BR_b = \frac{11,490 + 4,379 + 6,504 + 14,753 + 16,105 + 14,812 + 9,015 + 13,142 + 13,064}{9} = 11,474 \]  
(T.5)

\[ BR_A = \frac{126,913 + 333,307 + 473,330 + 479,895 + 92,984 + 170,736 + 228,545 + 392,822 + 852,504}{9} \]  
(T.6)

\[ VBR_b = \frac{(11,490 - 11,474)^2 + (4,379 - 11,474)^2 + (6,504 - 11,474)^2 + (14,753 - 11,474)^2 + (16,105 - 11,474)^2 + (14,812 - 11,474)^2 + (9,015 - 11,474)^2 + (13,142 - 11,474)^2 + (13,064 - 11,474)^2}{8} \]  
(T.7)

(T.8)

These results correspond to the numbers presented in Table 7.3.
Appendix U

Calculations Developed to Obtain the Information Presented in Table 7.7

The objective of this Appendix is to explain how the information presented in Table 7.7 was calculated. For this purpose, consider the information presented in the following Table:

<table>
<thead>
<tr>
<th>Observation (i)</th>
<th>Expected Gross Margin of the portfolio of crops (£/ha)</th>
<th>Variance of the portfolio of crops (£²/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before the shock (GMₜ₀)</td>
<td>After the Shock (GMₐ₀)</td>
</tr>
<tr>
<td>2</td>
<td>327.55</td>
<td>322.40</td>
</tr>
<tr>
<td>10</td>
<td>476.95</td>
<td>472.52</td>
</tr>
<tr>
<td>11</td>
<td>312.66</td>
<td>309.20</td>
</tr>
<tr>
<td>12</td>
<td>458.82</td>
<td>473.60</td>
</tr>
<tr>
<td>14</td>
<td>329.08</td>
<td>330.68</td>
</tr>
<tr>
<td>15</td>
<td>333.88</td>
<td>319.51</td>
</tr>
<tr>
<td>17</td>
<td>386.95</td>
<td>379.42</td>
</tr>
<tr>
<td>18</td>
<td>593.71</td>
<td>604.54</td>
</tr>
<tr>
<td>19</td>
<td>332.59</td>
<td>352.18</td>
</tr>
<tr>
<td>22</td>
<td>369.78</td>
<td>333.36</td>
</tr>
<tr>
<td>23</td>
<td>347.85</td>
<td>349.45</td>
</tr>
<tr>
<td>26</td>
<td>374.51</td>
<td>366.85</td>
</tr>
<tr>
<td>38</td>
<td>371.25</td>
<td>343.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>39</td>
<td>347.86</td>
<td>365.38</td>
</tr>
<tr>
<td>44</td>
<td>364.40</td>
<td>354.04</td>
</tr>
<tr>
<td>48</td>
<td>328.03</td>
<td>339.42</td>
</tr>
</tbody>
</table>

The second column of Table 7.7 was obtained by subtracting the second column of Table U.1 from the third column of this table. For example, the change of expected gross margin for observation 11 is given by \(dGM_{11} = 309.20 - 312.66 = -3.46\). On the other hand, the third column of Table 7.7 was obtained by subtracting the fourth column of Table U.1 from the fifth column of the same table. For example, the change of variance or business risk for observation 11 is given by \(dBR_i = 13,499.42 - 13,869.52 = -370.10\).