

The impact of technology orientation, strategic firm resources and resource orchestration on small high-tech firms innovation: evidence from the UK

Item Type	Thesis or dissertation
Authors	Aguda, Akinbowale
Citation	Aguda, A. (2024) The impact of technology orientation, strategic firm resources and resource orchestration on small high-tech firms innovation: evidence from the UK. University of Wolverhampton. http://hdl.handle.net/2436/625817
Publisher	University of Wolverhampton
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Download date	2025-06-12 10:01:54
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Link to Item	http://hdl.handle.net/2436/625817

**The Influence of Technology Orientation, Strategic Resources and
Resource Orchestration on Innovation in Small High-tech Firms:
Evidence from the UK**

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A thesis submitted in partial fulfilment of the requirements
of the University of Wolverhampton for the Degree of
Doctor of Philosophy

July 2024

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Abstract

Innovation is the driving force of a high-tech small business and plays a vital role in developing the firm's competitiveness and achieving sustainable growth. High-tech firms are a significant force for innovation as they are primarily private firms and the main foundation of the UK private sector. This thesis endeavours to unravel the innovation dilemma of high-tech firms by examining how strategic firm resources and the use of these strategic firm resources are exploited in their innovation process to achieve innovation performance. Firstly, this study draws upon the resource-based view and resource orchestration theory to examine how technology orientation influences innovation performance. Secondly, this study examines the impact of strategic firm resources (availability of technological resources, availability of financial resources, networking capability, and degree of openness) on the relationship between technology orientation and innovation performance. Thirdly, this study examines the role of resource orchestration (structuring, bundling, and leveraging) between the availability of strategic firm resources and innovation performance.

Based on a quantitative study, this thesis examines the mechanism of the innovation process using quantitative survey data from 141 high-tech small and medium-sized enterprises (SMEs). The key findings of this thesis revealed that technology orientation positively impacts innovation performance. Furthermore, the results show that the availability of technological resources, networking capability, and the degree of openness positively affect the nexus of technology orientation and innovation performance. In contrast, the availability of financial resources does not positively impact the relationship between technology orientation and innovation performance.

Furthermore, other key findings show that resource orchestration (structuring, bundling and leveraging) impacts the relationship between the availability of strategic firm resources and innovation performance. Specifically, structuring, bundling and leveraging positively and partially mediate the relationship between strategic firm resources (availability of technological resources, networking capability, and degree of openness) and innovation performance. However, regarding the availability of financial resources, structuring has a negative impact on the relationship between the availability of financial resources and innovation performance, whilst bundling and

leveraging have a full mediating effect on the relationship between the availability of financial resources and innovation performance.

This research extends the understanding of the innovation process in high-tech small firms by exploring the role and orchestration of resources. It tackles the problem of how high-tech firms can achieve innovation performance with scarce resources. Moreover, it enhances the literature on UK high-tech firm's innovation, which provides new knowledge about high-tech business in a developed country, contributing to a more holistic picture of high-tech business innovation worldwide. Finally, the study makes a methodological contribution to the study of the innovation performance of high-tech firms by providing a comprehensive understanding of the innovation performance in UK high-tech small firms as it examines two levels of the mediating effect of availability of strategic firm resources and orchestration of strategic firm resources and integrating both resource-based view and resource orchestration theory.

Acknowledgement

The past five years of my PhD programme have been an incredibly humbling journey, and it is one of the most valuable and unforgettable periods in my life. I could not have achieved this dream without the help of so many people. Firstly, I am thankful to God, who gave me the strength and courage to complete this research. Secondly, I would like to express my sincere gratitude to those who helped and supported me throughout this PhD programme. My most profound appreciation goes to my supervisors, Professor Yong Wang (Director of Studies) and Dr Osagie Igbinigie as Second supervisor. Also, I would like to thank Dr Gavin Smeilus, my initial first supervisor and Director of Studies, for three years but unfortunately had to depart from the University. During my PhD, they devoted thousands of hours to my research and reviewed countless drafts, enabling me to understand my subject and become a better researcher. I would not be where I am without their guidance, motivation and support. It is my great honour to be their doctoral student. I am grateful to the University of Wolverhampton Business School for providing me with an excellent environment in which to conduct research. I want to express my sincere thanks to Dr Benjamin Halligan, Dr Janet Firth, Dr Jenni Jones, Dr Shaukat Ali, and Dr Anna Korzhenitskaya for their continual support. I thank all my fellow PhD researchers at the University of Wolverhampton Business School. Thanks to Dr Afusat Jaiyeola, Dr Matthias Aku, Dr Singh Guriqbal, Begonya Ebot, and Ifeoma Onoja for their kind support and encouragement.

Finally, my special thanks go to my parents. No words can express my gratitude for their encouragement and support throughout my life and studies.

List of Abbreviations and Acronyms

CEO – Chief Executive Officer

CFA - Confirmatory Factor Analysis

CFI - Comparative Fit Index

CMB – Common Methods Bias

EU – European Union

FAME – Financial Analysis Makes Easy

IFI – Incremental Fit Index

IP – Innovation Performance

OECD – Organisation for Economic Co-operation and Development

OI – Open Innovation

R&D – Research and Development

RBV – Resource Based View

RMSEA – Root Mean Square Error of Approximation

ROT – Resource Orchestration Theory

SEM – Structural Equation Modelling

SMEs – Small and Medium Sized Enterprises

SPSS – Statistical Package for Social Science

TO – Technology Orientation

TLI - Tucker–Lewis Index

UK – United Kingdom

List of Key Definitions

The following key terms and constructs will be used and referenced throughout this thesis:

High-tech SME

High-tech SMEs are “generally characterised as small and medium-sized firms with advanced knowledge and capabilities in technology, an educated workforce, and the ability to adapt to fast-changing environments” (Crick and Spence, 2005, p. 168).

Technology Orientation

Technology orientation is defined as the “use of sophisticated technologies in new product development, the rapid integration of new technologies, and proactively developing new technologies and creating new product ideas” (Gatignon and Xuereb, 1997, p. 78).

Innovation Performance

This thesis defines innovation performance as developing new and improved products, services, and processes.

Strategic firm resources

A strategic firm’s resources are available inputs or factors, both tangible and intangible, that are owned and managed by the firm. Firms need resources for their basic operations (Nohria and Gulati, 1998; Hoegl, Gibbert, and Mazursky, 2008). Internal firm resources can positively impact the process of innovation (Penrose, 1959). Similarly, strategic firm resources are essential for innovation (Ahuja, 2000). This thesis focused on four strategic firm resources related to innovation performance, including the availability of technological resources, financial resources, networking capability and degree of openness.

Resource-Based View Theory

The resource-based view theory states that a firm can achieve a competitive advantage if it possesses valuable, rare, inimitable, and non-substitutable resources (Barney, 1991).

Resource Orchestration Theory (ROT)

Resource orchestration theory is an extension of the resource-based view. It considers the role of managers in structuring a firm's resource portfolio, bundling them into capabilities, and finally leveraging those capabilities (Sirmon, Hitt, and Ireland, 2007; Sirmon *et al.*, 2011).

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CHAPTER 1: INTRODUCTION TO THE RESEARCH

1.1 Outline of the Research

Technological advances and increasing globalisation drive the global economy and are critical factors in facilitating growth and transforming business competitiveness (Drucker, 1985; Hamel, 2000; Morrison, 2002; Prange and Pinho, 2017). As a result of technological advances, high-technology firms play a vital role in a nation's social and economic landscape (O'Regan and Sims, 2008; Aydalot and Keeble, 2018). High-technology firms with their products are expanding quickly in international trade, and their dynamics help improve efficiency in other sectors (Hatzichronoglou, 1997; Roper, 1997; Wonglimpiyarat, 2015; Jurak, 2020). Furthermore, high-technology firms can catalyse economic growth (Wynarczyk *et al.*, 1993; Rothwell & Dodgson, 1994; Surya *et al.*, 2021).

In developed countries, high-tech firms notably contribute to the growth of the economy. For example, investment in research and development, innovation and skills is a crucial policy area for the UK, as it is essential for the economic growth and the development of a knowledge-based economy (Oakey and Mukhtar, 1999; Weaver, 2008; Yoo *et al.*, 2012; Mason and Brown, 2013). The UK technology sector, for example, employs 1.7 million people and adds over £150bn to the UK economy every year, which could grow to a further £41.5 billion and create 678,000 additional jobs by 2025 (Diversity in tech, 2024). Even though high-tech firms have significant economic value, there is limited research on them in the UK (Wang and Rafiq, 2014; Cowling, Liu and Zhang, 2021).

High-technology firms are “the firms with high dependence on science and technology innovation with above-average research and development (R&D) intensity and an above average proportion of scientists, engineers and technicians in the labour force, for the creation of new or improved products and services” (Butchart, 1987, p103). Industries that are high-tech rely significantly on a skilled workforce and technology for new or improved products and services (Steenhuis and Bruijn, 2006; Schwab and Martin, 2016). The level of firm performance at high-technology SMEs increases depending on their concentration on technology, product change, and the market (Pavia, 1991). Despite their limited resources for high-technology SMEs, they can

develop their innovation abilities through learning and external networks, helping them to adapt to technological change and thus innovate (Mohannak, 2007).

Innovation is an essential contributor to the competitive advantages of SMEs in the high-technology sector; conversely, a significant constraint to continued growth appears to be a lack of abilities and resources, such as finance and technology (Mohannak, 2007; Bessant and Tidd, 2013). As innovation continues to reshape the competitive environment and open new windows of opportunity, Researchers have proposed various approaches to identify what drives innovation (Isobe *et al.*, 2008; Lau and Bruton, 2011). One such approach emphasises the role of strategic firm resources in the innovation process (Barney, 1991). Scholars have focused on how a firm's strategic resources affect overall innovation (Keizer, Dijkstra, and Halman, 2002; Alerasoul *et al.*, 2022). These scholars also acknowledge that different types of strategic firm Resources are very important in a firm's innovation process and performance (Keizer, Dijkstra, and Halman, 2002; Alerasoul *et al.*, 2022). For SME managers, the problem is acquiring, integrating and exploiting their scarce resources in unique ways to provide their firms with innovation capability and, therefore, superior innovation performance (Stringer, 2000; Saqib, Zarine, and Udin, 2018). In terms of business performance in this situation, innovation performance becomes attractive, which can support further economic growth (Reshetnikova, 2018). Given the importance of high-tech firms for UK economic development, it is thus crucial to understand UK high-tech firms' technology orientation, resource management and innovation performance.

1.2 The Rationale for Research

An established body of studies suggests that innovation in high-tech firms is essential because innovation, as the key driver of a firm's survival, plays a vital role in part in boosting a company's ability to compete and achieve long-term growth (Surya *et al.*, 2021). In high-tech firms, innovation is the lifeblood (Scholes *et al.*, 2021) due to the characteristics of the high-tech firms, such as competing in a globalised and dynamic environment. The technology industry has experienced unparalleled growth in recent years, which is altering people's thoughts, lifestyles, and behaviors in many spheres of their existence. Many small businesses are innovating, and by developing cutting-edge goods and services, many smaller businesses have grown into large

corporations in a matter of years. Notably, there has been a significant increase in research on innovation in high-tech SMEs, leading to a growing body of publications (Oluwafemi, Mitchelmore, and Nikolopoulos, 2020; Tian *et al.*, 2021; Jafari-Sadeghi *et al.*, 2022; Tong and Rahman, 2022). Firms compete because of the globalised business environment where market conditions and the needs of customers are changing rapidly, and the need for new markets is essential (Grunbaum, N.N, and Stegner, 2013). Furthermore, new challenges are continually emerging and are forcing firms to re-examine their internal environments to maintain a competitive edge and improve their performance (Almajali *et al.*, 2016). A firm's strategy has significant consequences for its structure, activities, investments, market relations, and performance (Valos and Bednall, 2010; Ajmal *et al.*, 2017). This strategy can help organisations deal with challenges, create new capabilities and improve firm and innovation performance (Sarker and Palit, 2015; Pang *et al.*, 2019; Lestari *et al.*, 2020) by providing a way that allows organisations and their managers to acquire specific resources, recognise opportunities for developing and delivering valued products and services that would result in organisational performance (Al-Ansaari *et al.*, 2015; Ashal *et al.*, 2021). For an organisation to adopt the best strategies, it needs to coordinate its approaches in establishing industry positions by relying on its resources, competencies, and capabilities to achieve fitness in its internal and external environments and, consequently, achieve innovative performance and sustained competitive advantage. In achieving these goals, organisations need to focus on their strategic orientations (Al-Ansaari *et al.*, 2015; Adewunmi *et al.*, 2017) because a firm's strategic orientation paves the way for its strategic direction to monitor its activities to achieve better innovation and business performance (Freitas *et al.*, 2013; Rahman *et al.*, 2018; Adams *et al.*, 2019).

In the UK, SMEs provide a substantial economic contribution to the UK, and 16.7 million people are employed, which is nearly 62% of the total number of people employed by private sector companies. Moreover, in 2023, SMEs had a turnover of £2.4 trillion, which is 53% of the total turnover of private businesses (Diversity in tech, 2024). Considered the pillars of the UK economy, SMEs continue to play an essential role in accelerating economic growth and currently contribute to the digital transition to address current competitive challenges in the context of economic digitisation (Diversity in tech, 2024). In the UK, the rapid development of information technology

(IT) over the last five years has changed the purchasing and consumption behaviour of the population, which has increased the development and innovation capability of SMEs to market needs, trends, and requirements. This supports the construction of a fair and competitive digital economy. Innovation efforts are now more important than ever as a source of competitiveness in the wake of the pandemic. Thus, it is necessary to comprehend the factors that contribute to innovation.

and the final impact on innovation performance in SMEs (Ramírez-Solis, Llonch-Andreu, and Malpica-Romero, 2022). Furthermore, as SMEs remain the primary contributors to the UK GDP, few studies have identified and examined the common role of specific factors in their performance, especially in the context of post-pandemic activity. Therefore, examining the factors that could enhance innovation performance remains vital. Scholars have suggested that technology and organisational resources can help SMEs grow, innovate, survive and achieve innovative performance (Adam, 2011; Gök and Peker, 2017; Jiang, Yang, and Gai, 2023; Hassan et al., 2024).

Technology orientation (TO) has gained particular attention from entrepreneurs, managers, and researchers. The integration of new technologies within SMEs could yield multiple long-term benefits, such as easy, fast, and efficient communication with stakeholders, efficient manufacturing techniques, reduced waste, effective inventory and ordering systems, new sales channels, and new capacities for developing innovative approaches (Gao et al., 2007; Mamduh and Pratikto, 2021). Scholars have discussed technology orientation among other critical strategic orientations (Li, 2005; Hakala, 2011; Lee, Choi, and Kwak, 2015; Ramírez-Solis, Llonch-Andreu and Malpica-Romero, 2022) due to the fact that it is essential for improving innovation performance (Gatignon and Xuereb, 1997; Zhou, Yim, and Tse, 2005). For instance, some studies reported a notable relationship between technology orientation and innovation performance (Gatignon and Xuereb, 1997; Zhou *et al.*, 2005; Liu and Chen, 2015) and other studies have reported an insignificant relationship (Hakala, 2011; Adams, Freitas, and Fontana, 2019). Thus, results concerning various research have found varying and inconsistent relationships between technology orientation and innovation performance. This problem represents a void in the body of literature, and further research is needed to understand how technology orientation influences innovation performance more accurately.

Given the mixed results and inconsistencies between the TO and Innovation performance relationship, A moderator or mediator could be considered to understand and strengthen the relationship as suggested by previous scholars (Baron and Kenny, 1986; Lee, Dedahanov, & Rhee, 2015; Adams et al., 2019). Some studies have selected moderators, such as technological innovation (Bagheri et al., 2019); technology (Saqib, Zarine, and Udin, 2018); learning Orientation (Salavou, 2010) and risk-taking propensity (Zhani, Mouri and Hamdi, 2021). Some studies have also considered mediating effects such as information technology adoption capability (Nugroho, Prijadi, & Kusumastuti, 2022), firm innovativeness (Yousaf et al., 2020) and dynamic capabilities (Rezazadeh, Karami, & Karami, 2016).

However, considering the context of these studies, some strategic resources are more important for small high-tech firms compared to other small firms, and little study has been found in the available literature that has considered the role of the availability of technological resources, the availability of financial resources, network capability and degree of openness in small high-tech firms (Satta et al., 2016; Lecerf and Omrani, 2020; Tong and Serrasqueiro, 2020; Atzmon, Vanderstraeten, and Albers, 2022; Daniel, 2023; Löfsten, Isaksson, and Rannikko, 2023). To address this void in knowledge. Thus, this study examines the mediating role of the availability of strategic firm resources and resource orchestration between TO and innovation performance. This study will benefit the managers of SMEs, regulators, and reference points for potential academic researchers.

Furthermore, literature shows that firms that operate in a dynamic environment must develop, prosper, and compete (Zahra and George, 2002; Gibb and Blili, 2013). Additionally, SMEs sometimes lack the resources to innovate like larger companies (Hudson *et al.*, 2001). As a result, enhancing a firm's innovation performance is becoming a goal, which makes SMEs' competitiveness more intense (Anggadwita & Mustafid, 2014). To enhance a firm's performance in terms of innovation, Strategic firm resources that could be internally developed and externally acquired and can provide a firm with the foundation to create capabilities are essential (Barney, 1991; Romano *et al.*, 2001; Chua *et al.*, 2011; Montresor and Vezzani, 2019). Barney (1991) argues that resources must create an advantage and be valuable, rare, inimitable and non-substitutable (VRIN). These resources must enable the company to implement measures that enhance its efficacy and efficiency in meeting customer needs. A firm's

competitive heterogeneity and performance compared to its close competitors result from the difference in resources and capabilities available (Helfat and Peteraf, 2003; Garousi Mokhtarzadeh *et al.*, 2020). These differences, in turn, affect performance and competitiveness. Kostopoulos *et al.* (2019) argue that sustainable competitive advantage results from resource selection, accumulation and deployment based on firms' resource heterogeneity.

Jansiti & Clark (1994) and Leonard-Barton (1997) contend that the presence of different organisational resources and capabilities positively affects the outcome of the innovation process. Strategic management scholars submit that internal strategic firm resources are the principal drivers of firm profitability and innovation performance due to new products, new technology, and changes in customer preferences. The innovation literature primarily discusses the potential link and benefits of firm resources for innovation (Song & Parry, 1997; Bharadwaj & Menon, 2000; Andal-Ancion *et al.*, 2003; Yam *et al.*, 2004; Yoo *et al.*, 2012; Clausen *et al.*, 2013; D'Este *et al.*, 2016; Landaeta Olivo *et al.*, 2016; Del Vecchio *et al.*, 2018; Bresciani, Ferraris, and Del Giudice, 2018; Ardito *et al.*, 2019; Montresor and Vezzani, 2019; Fitzgerald *et al.*, 2021). Several studies also reported that firm resources open opportunities for innovation by capturing value (Nambisan *et al.*, 2017; Scuotto *et al.*, 2017; Bonfanti *et al.*, 2018; Garousi Mokhtarzadeh *et al.*, 2020; Saviano *et al.*, 2021). Some studies have shown that different internal strategic organisational resources positively affect the innovation process (Bakar and Ahmad, 2010; Yoo *et al.*, 2012; Espocito De Falco and Renzi, 2015). Firms with more available resources are more likely to take advantage of new opportunities and thus invest more in innovation than those with resource limitations (González-Bravo, López-Navarro, and Rey-Rocha, 2021).

For example, Yoo *et al.* (2012) suggested that strategic firm resources are drivers of innovations characterised by convergence and generativity. Bakar and Ahmad (2010) showed in a study of 700 SMEs in Malaysia that intangible resources are the main drivers of product innovation performance. Also, strategic firm resources (e.g., engineering and production equipment, manufacturing facilities, IT systems) have been found to influence innovation positively (Song and Parry, 1997). Montresor and Vezzani (2016) showed that acquiring more strategic firm resources for R&D activities could result in new products and services. However, some studies have shown

inconclusive results on the role of strategic firm resources in innovation performance (Rosenzweig & Grinstein, 2016; Lember *et al.*, 2019). Along this line, some scholars argued that resource limitations do not impede a firm from achieving innovation, especially in small firms (Berends *et al.*, 2014; Bicen and Johnson, 2014; De Massis *et al.*, 2018).

For instance, De Massis *et al.*, 2018 suggest that small firms can still achieve some innovation even with limited availability of resources. Therefore, it is essential to understand how strategic firm resources influence innovation performance more accurately. Also, there is still a gap in understanding how small firm managers acquire, organise, and exploit firm resources for innovation performance. The intention of this study is to contribute to the literature by investigating the role of strategic firm resources in the relationship between technology orientation and innovation performance in high-tech SMEs. As Keupp and Gasmann (2013) and Weiss, Hoegl and Gibbert (2017) suggest, despite several studies researching the role of strategic firm resources in a firm's innovation performance, the extent to which the availability of resources is orchestrated to achieve more innovation performance remains unclear.

Although numerous studies have placed a high emphasis on the role that resources play in helping organizations achieve their innovation performance, as explained in the previous paragraphs. Nevertheless, only a few strategic management literature have examined the role of managerial actions in leveraging these resources to achieve competitive advantage and innovation performance (Miller, Fern, & Cardinal, 2007; Sirmon *et al.*, 2007; Bridoux, Smith, & Grimm, 2013; Li & Jia, 2018; Tikas, 2023). The literature stresses the need to implement actions to utilise resources and capabilities. Such an idea posits that resources are the enablers of actions (Ndofor, Sirmon, and He, 2011). As a result, actions transform resources (Zhou *et al.*, 2008). Resources per se do not influence performance; in return, actions transform resources (Sirmon *et al.*, 2007; Ndofor, Sirmon, and He, 2011).

Kauppila (2015) argues that although “possessing strategic resources is necessary, it is not sufficient because firms must also take appropriate actions to utilise these resources. Strategic actions must be taken to leverage capabilities”. In other words, the actions describe what a firm does, and the capability determines how well the firm can perform this action. The potential value of resources is realised by leveraging

actions on them (Ketchen, Ireland, & Snow, 2007; Sirmon *et al.*, 2007; Combs *et al.*, 2011). Therefore, this approach differentiates between resource ownership and exploitation (Newbert, 2007; Jafari-Sadeghi *et al.*, 2019a, 2019b) and explains why some firms have performance differences despite possessing similar resources and capabilities (Zott, 2003). Therefore, a framework to investigate strategic actions could lead to maximum utilisation of resources and implementation of organisational strategies (Miller, Fern, & Cardinal, 2007). Based on these theoretical foundations, this study investigates how small high-tech firms' resource orchestration (structuring, bundling and leveraging) achieves innovation performance. Therefore, developing a better understanding of this knowledge is more important than ever because it can inform scholars and practitioners with policies that support firms to innovate more effectively (Morgan *et al.*, 2020; Roper, 2020). The following section discusses the aims, the objectives, and the research questions.

1.3 Aims and Objectives of the Thesis

Based on the literature review and having strategic firm resources as a core element, this study examines the role of the availability of strategic firm resources and resource orchestration between technology orientation and innovation performance in high-tech SMEs in the UK. This study attempts to provide a comprehensive picture of high-tech small business innovation performance and the factors influencing it.

1.3.1 Research Objectives

The objectives of the study are:

- To examine the influence of technology orientation on the innovation performance of small high-tech businesses.
- To investigate if strategic firm resources have a role in the effects of technology orientation on the innovation performance of small high-tech businesses and
- To investigate if resource orchestration has a role in the effects of the availability of strategic firm resources on the innovation performance of small high-tech businesses.

1.3.2 Research Questions

The following research questions will be answered based on the data analysis to fill the gaps identified in the existing literature and reach the research aims and objectives.

Research question 1: What is the relationship between technology orientation and innovation performance in high-tech SMEs in the UK?

Research question 2: What is the role of availability of technological resources in the relationship between technology orientation and Innovation performance?

Research question 3: What is the role of availability of financial resources in the relationship between technology orientation and Innovation performance?

Research question 4: What is the role of networking capability in the relationship between technology orientation and innovation performance?

Research question 5: What is the role of the degree of openness in the relationship between technology orientation and innovation performance?

Research question 6: How does resource orchestration influence the relationship between the availability of technological resources, financial resources, networking capability and openness and innovation performance in high-tech SMEs in the UK?

1.4 Contributions to Knowledge

By disentangling the role of technology orientation, strategic firm resources and innovation process of UK high-tech firms, this thesis yields several contributions to the research on high-tech business innovation. It contributes to an increased understanding of the development of a conceptual framework that examines the impact of the availability of strategic firm resources (availability of technology resources, availability of financial resources, networking capability, and degree of openness and resource orchestration (use of strategic firm resources) on the relationship between technology orientation and innovation performance in small high-tech firms. This thesis introduces new evidence on the relationship between a firm's technology orientation and innovation performance as mediated by the availability of strategic firm resources. In addition, new evidence on the relationship between a firm's

availability of strategic resources and innovation performance is mediated by resource orchestration in the context of high-tech SMEs in the UK. This thesis provides theoretical and empirical contributions to high-tech business research.

Firstly, while some studies found that technology orientation has positive effects on innovation performance (Gatignon and Xuereb, 1997; Zhou *et al.*, 2005; Lee, Dedahanov, and Rhee, 2015), others reported inconclusive results (Gao *et al.*, 2007 Hakala, 2011). This study showed from empirical results that technology orientation has a positive and significant relationship with innovation performance in high-tech firms. There is a contribution to knowledge by establishing that the more a firm is technology-oriented, the more innovation performance it can achieve.

Secondly, this study contributes to knowledge by establishing the effect of the availability of strategic firm resources on the relationship between technology orientation and innovation performance. The study demonstrates that the availability of strategic firm resources mediates the relationship between technology orientation and innovation performance in small high-tech firms. The study further demonstrates that the availability of financial resources does not positively mediate the relationship between technology orientation and innovation performance in small high-tech firms.

Thirdly, this thesis extends the literature on empirical evidence of high-tech business innovation performance, availability of strategic firm resources and resource orchestration (structuring, bundling and leveraging). Specifically, this thesis examines the indirect role of structuring, bundling and leveraging between the availability of strategic firm resources and innovation performance in small high-tech firms, which provides new empirical findings for the relationship between the availability of strategic firm resources and innovation performance in high-tech firms.

Lastly, high-technology SMEs have become crucial to the economy's success and are creators of unique technologies. However, it is essential to manage innovation successfully with the right strategy to be successful in a globally competitive market. However, there are limited research studies on innovation performance in high-technology SMEs in the UK, and this study addresses this gap. This research explicitly addresses how the availability and use of strategic firm resources impact the innovation performance of technology-oriented high-technology SMEs in the UK from

internal and external factors and develops a framework to advance academic research and knowledge in this research area. The framework will also help scholars, practitioners, and policymakers develop an appropriate technological framework for innovation performance.

1.5 Organisation and Structure of the Thesis

The overall structure of this thesis is nine chapters, including this introduction chapter. The chapters are structured as follows:

Chapter 1: Introduction discusses the background and motivation for the research, the aim, contributions, and scope of the study, the research questions and objectives, the research contribution, research methods and analyses, the study in context, the research contribution, and the limitations of the study and thesis outlined.

Chapter 2, Research Context (SMEs and the IT sector), provides the overall understanding of the background contextual frame of the thesis. This thesis focused on small and medium-sized businesses in the UK. Reviewing the history of SMEs helps to enhance the contextual understanding of how SME businesses thrive and innovate in the UK. Also, the chapter defined what innovation is, types of innovation, drivers of innovation in firms, the innovation process, and the different innovation models.

Chapter 3: The Literature Review Part 1 discusses technology Orientation. Part 2: Introduction of innovation performance reviews the existing literature on innovation performance in SMEs, its definition, characteristics, and the factors that contribute to driving innovation performance. Part 3: The role of strategic firm resources such as technological resources, financial resources, networking capability, and degree of openness. The chapter then identifies the gaps in the literature regarding this study.

Chapter 4: Theoretical Framework and Research Hypothesis This section develops the theoretical framework and research hypotheses based on the research question. By drawing on a research-based view and Resource Orchestration theory, this study proposes a conceptual model to examine the impact of technology orientation on innovation performance, the role of strategic firm resources (technological resources, financial resources, networking capability and degree of openness) between

technology orientation and innovation performance, and finally the role of resource orchestration (structuring, bundling and leveraging) between availability of strategic firm resources and innovation performance.

Chapter 5: Research Methodology This chapter discusses the research methodology and justifies this thesis's philosophical position, research approach, research method and design. There is a discussion on the rationale for the chosen method. Furthermore, this chapter also describes the sample framework and data collection process, including an overview of the sample source, sampling procedure, and the steps of collecting the quantitative data. Finally, this chapter presents the detailed instrument construction, variable measurement, and the piloting process.

Chapter 6 presents a detailed analysis of the collected data and results, including a quantitative survey of 141 SMEs. It specifically provides a thorough analysis of the survey data, including descriptive statistics, the testing of hypotheses, and the discussion of the results.

Chapter 7 The last chapter of the research concludes the findings and highlights the theoretical and practical contributions to businesses that emerged from this study. In addition, the limitations of the research are acknowledged and then followed by suggestions for avenues for future research.

1.6 Chapter Summary

The background of this thesis has been laid out in this chapter. The chapter identifies the significance of high-tech firms and goes on to point out that small firms difficulties in gaining access to strategic firm resources. Because there has not been much research done in the UK setting, the lays out the necessity for more research in this field. To give readers some context, the chapter also describes the aims and objectives of the study as well as the structure of the thesis. The next chapter, therefore, provides some economic background information on the UK.

CHAPTER 2: RESEARCH BACKGROUND - UK CONTEXT

2.1 Introduction

The previous chapter provided an outline of this study. It provided the background, justification for the research, aims and objectives of the study, and the research questions. Along with the study's contributions, the knowledge gaps in the present literature relating to the constructs addressed in this study were also emphasized. This chapter briefly discussed the role and importance of small businesses, defining the small business, the UK Definition of SMEs, and High-Technology SMEs. The chapter then concluded with a summary.

2.2 The role and importance of small businesses

SMEs represent an essential economic force that contributes to the creation of jobs, income growth, export generation, and the growth of the economy (Nesta, 2017). Small businesses remain vital in every industrial economy (Curran, Stanworth, & Watkins, 1986). In the UK, SMEs are a major driving force in every primary sector of the economy and continue to provide significant employment in traditional and non-traditional established industries such as construction and professional and scientific services (Binks and Coyne, 1983; Davidsson and Wiklund, 2017). These firms also make significant contributions to private sector output and employment, a contribution which appears to be increasing over time (Storey, 1994). The SME sector in the United Kingdom represents one of the British economy's most notable and vital elements (Clark, 2024).

Moreover, according to the Department of Business, Energy, and Industrial Strategy, it accounts for 5.56 million private businesses at the start of 2024 (Clark, 2024). SMEs have served crucial roles throughout the recovery of the UK economy after the 2008 economic crisis and, more recently, the COVID crisis. SMEs continue to be critical to the future success of the nation's growth and stability. Therefore, the growing focus on the development of SMEs has been on the value they contribute to the economy compared to large firms in the context of jobs, innovation, growth, efficiency, and exports. However, despite their roles in promoting economic growth and development, they are not without challenges.

2.3 Defining Small Business

Initially, there was no universally acceptable definition of a small firm (Storey, 1994). Various definitions of a small firm apply to different contexts. Indeed, Curran, Stanworth, & Watkins (1986, p.3) refer to the 'great deal of agonising' over the issue of definition by small business theorists and researchers, such as Bolton (1971), Binks and Coyne (1983) and Stanforth and Stanworth (1990) from which no satisfactory solutions have emerged. One reason for this relates to size – for example, where a 'small' firm such as the petrochemical industry will probably have much higher sales, capitalisation, and employment levels than a 'small' firm such as a car repair firm. Thus, definitions at the sectoral level linked to 'objective' measures of size - such as number of employees, sales turnover, profitability, and net worth - may imply that in some sectors, all firms may be negligible. In contrast, in other sectors, they are possibly considered not to be small (Storey, 1994). The following sections will examine the debate concerning the definition of small business by the Bolton Committee Report (1971) and the UK Department of Trade and Industry.

2.3.1 Defining Small Business: Bolton committee definition.

The Bolton Committee produced a statistical and economic definition of small business in 1971 (Bolton, 1971). The Bolton Committee's Report on Small Business (1971) is one of the most widely quoted sources of definitions and understandings of the small business sector. The committee tried to solve the problem of defining small businesses by introducing an 'economic definition' and a 'statistical' definition.

The economic definition viewed firms as being small if they fulfilled the three benchmarks below:

- They controlled a small share of the marketplace.
- They are independent and are not part of a big enterprise.
- Owners or part-owners govern them individually, not through a formal management structure.

Based on this economic definition, Bolton developed a statistical explanation to solve three fundamental problems. The first purpose was to value by quantifying the present size of the small firm sector and its significance to economic factors such as

innovation, exports, employment, and gross domestic product. The second purpose was to contrast the level to which the contribution of the small firm sector to the economy has not been the same over time. Thirdly, the statistical explanation, in general, must allow a comparison between the contributions of firms in one country and those of other countries. The Bolton committees' definitions, which are adopted, are revealed in table 2.1. The table shows the yardstick for defining small firms in different sectors. It also indicates that the template upon which the judgment of small firms was made also differed by industry. Accordingly, in two sectors – mining and quarrying, manufacturing, and construction – employment is the yardstick; in three service sectors, the sales turnover is the yardstick, and in the catering sector – ownership is the yardstick. Finally, the firm's physical assets, such as the number of cars, are the yardstick in the road transport sector (Bolton, 1971).

Table 2.1 Bolton Committee definitions of a small firm

Sector	Definition
Manufacturing	200 employees or less
Construction	25 employees or less
Mining and quarrying	25 employees or less
Retailing	Turnover of £50,000
Miscellaneous	Turnover of £50,000
Services	Turnover of £50,000
Motor trades	Turnover of £100,000
Wholesale trades	Turnover of £200,000
Road transport	Five vehicles or less
Catering	All excluding multiple and brewery-managed houses.

Source: Bolton (1971)

This debate has criticisms for both the economic and statistical definition; for example, the Bolton criterion that a small business is 'managed by its owners or part-owners in a personalised way, and not through a formal management structure' does not align with its 'statistical' definition of small manufacturing firms as having up to 200 employees (Storey, 1994). Nevertheless, the details of the criticisms are beyond the scope of this study.

2.3.2 How Small Firms Are Different from Large Firms

An alternative economic idea for defining a small firm differed from that provided by Bolton Wynarczyk et al. (1993). Drawing from the knowledge of Penrose (1959) that

small and big firms are fundamentally different from each other. They tried to identify the characteristics of small firms instead of size, differentiating them from big firms. Here, Wynarczyk et al. (1993) and Tonge (2001) suggest three key ways in which small firms differ from big firms: uncertainty, innovation, and evolution.

I. Uncertainty: Concerning 'uncertainty', three dimensions are identified:

The first is the uncertainty connected with being a price-taker, which can be considered the inverse of the Bolton definition, which stresses the small share of the marketplace. The second source of uncertainty for small firms is their inadequate product and customer base – a classic example is where small firms act as subcontractors to larger firms. Such firms are open to 'subcontractor vulnerability' (Lyons and Bailey, 1993), which is developed not only by dependence on dominant customers but also upon the extent to which output is specialised to the investment decisions made, customers, and the probability that the customer will withdraw the custom (Tonge, 2001). Even for the whole subcontractors, the smaller firm views itself as vulnerable compared to the larger firm and acts appropriately (Lyons and Bailey, 1993). The third dimension of uncertainty connects to the much more significant difference of objectives among small business owners in contrast to those of large businesses. Many owners of small businesses seek only to attain a minimum income level, preferably to maximise sales or profits (Storey 1994).

Small business owners do not have to worry about reporting their actions to external shareholders; therefore, 'performance monitoring' is effectively non-existent. For a small firm, the business and the owner relationship is much closer than between the shareholder and the big firm. Thus, the motivation of the owner of the small firm is a crucial influence on the small firm's performance (Storey, 1994). This contrasts with the literature on big firms, which stresses the relevance of control. Here, the main challenge is how the business owners guarantee that the business managers act in their interest and how senior managers influence junior managers. This form of 'internal' conflict is mainly absent in small firms (Storey, 1994), where control and ownership are in the hands of a few people or even a single person. For that reason, the central distinction between large and small firms is considered the more significant external environmental uncertainty in which the small firm operates, in addition to the greater internal consistency of its motivations and actions (Storey, 1994).

ii. Innovation

A second key area of difference between small and large firms is their role in innovation. Traditionally, small businesses' contribution to innovation is associated with their "niche" function. where: "the small firm can offer a somewhat unusual product or service that sets it apart from the more standardised offerings provided by, the larger firm" (Storey, 1994: pg. 11-12; Bjerke and Johansson, 2015). Fundamentally novel inventions are more likely to be introduced by small businesses than by larger ones. A feature often associated with small firms having less commitment to extant practices and products (Pavitt *et al.*, 1987; Spithoven, Vanhaverbeke, and Roijackers, 2013).

iii. Evolution

The third area of difference between a large and small firm is the smaller firm's significantly higher chance of evolution and change (Storey, 1994). Management theorists (e.g. Scott and Bruce, 1987) see the transitions made by small firms into becoming larger ones as a multiple-stage change, unlike Penrose (1959), who views it as a single-stage change. Therefore, small firms that become larger undergo many stage changes impacting the role, management style, and organisational structure (Scott and Bruce, 1987). The critical point is that the small firm's structure and organisation are more likely to change as the firm moves from one stage to another than firms that are larger (Storey, 1994). Uncertainty, innovation and firm evolution are therefore the important dimensions in which small firms differ from larger firms. They should be explored as a 'bottom-up' way of theorising about small firms rather than implicitly assuming that a small firm is a 'scaled down' version of a bigger firm (Wynarczyk et al., 1993).

2.3.3 UK Department of Trade and Industry

The Department of Trade and Industry (DTI) defines business size according to the number of employees in the organisation, an approach commonly used in academia and the field. Here, a micro business has 0-9 employees, a small business has 10-49 employees, and a medium-sized business has 50-249 employees.

According to The DTI's (DTI, 2000a) statistical information concerning SMEs, there is no single definition of a small firm because of the wide diversity of businesses. It

maintains that the best description of the critical characteristics of a small firm remains that used by the Bolton Committee in its 1971 Report on Small Firms (DTI, 2000a). However, various criticisms of the report have already been highlighted. Section 248 of the Companies Act 1985 states that a company is “small” if it satisfies at least two of the following criteria:

- a turnover of not more than £2.8 million
- a balance sheet total of not more than £1.4 million and not more than 50 employees.

A medium-sized company must satisfy at least two of the following criteria:

- a turnover of not more than £11.2 million, a balance sheet of not more than £5.6 million and not more than 250 employees. For statistical purposes, the DTI uses the following definitions: a micro firm with 0-9 employees, a small firm with 0-49 employees (includes micro), and A medium firm with 50-249 employees. Furthermore, “The Companies Act 2006 defines a large company by its staff headcount threshold: over 250 staff, and either its annual turnover exceeding £36m or its balance sheet total exceeding £18m”. The following section examines how the Companies Act 2006 defines SMEs in the UK.

Companies Act 2006 Definition

This definition is vital for companies, as it dictates which accounts they can or should file with Companies House. The Companies Act 2006 classifies SMEs into micro, small, and medium-sized categories. To indicate which title a company falls under, they must meet two of the conditions in the bands noted below (note that the Companies Act 2006 bands use £, so, thus, escapes any post-Brexit red tape that the Government’s definition will undoubtedly encounter. Table 2.2 presents the classification.

- Micro entity – annual turnover of no more than £632,000, a balance sheet total of not more than £316,000 and not more than ten employees.
- Small company – annual turnover of no more than £6.5 million, a balance sheet total of £3.26 million, no more than 50 employees.
- Medium-sized company – annual turnover of no more than £25.9 million, a balance sheet total of no more than £12.9 million, no more than 250 employees.

Table 2.2: Definition of SMEs according to the Companies Act 2006

Size of Business	Staff Headcount	Annual Turnover	Balance Sheet Total
Medium	Under 250	No more than £25.9 million	No more than £12.9 million
Small	Under 50	No more than £6.5 million	No more than £3.26 million
Micro	Under 10	No more than £632,000	No more than £316,000

Source: (Department for Business, 2023)

The Companies House 2006 definition of an SME is the adopted definition of an SME in this thesis.

2.4 High-Technology Small and Medium Firms

High technology firms have captured a disproportionate share of the international spotlight in recent years, as businesses, investors and policymakers believe in their indispensable role for economic prosperity in the developed and developing nations. To many, high technology firms have become the economic holy grail of the twentieth century (Glasmeier, 1988; Kodama, 2005). There was initial disagreement on the definition of a high technology-based firm. The reason is that using different criteria and characteristics has resulted in different definitions (Brown and Mason, 2014). A firm characteristic is based on the features of the firm (Brown and Mason, 2014). An example of these characteristics is success in exploiting emerging or niche technologies or market and R&D intensity (Glasson, Chadwick, & Smith, 2006). Technology-based firms are supposed to have most of these characteristics. A definition of firm characteristics for the research would be limited because it requires a massive amount of firm-level information, which is difficult to access and may not even exist. The definition tilts towards big firms. Also, R&D expenditures and technology occupations are not well pronounced in small firms (Brown and Mason, 2012).

Firm characteristics-based definitions are also subjective. For instance, Brown and Mason (2012, p. 13) raised the question when the Sunday Times Fast Track defined

a high-tech firm “as one whose business growth and success is dependent on the development of one or more technologies.” They raised the question of what “dependent” and “technology” mean (Brown and Mason, 2012, p. 13). They think the definition based on a firm's characteristics is unrealistic (Brown and Mason, 2012). Glasson, Chadwick, and Smith (2006) defined technology-based small firms based on the Butchart (1987) standard industry classification (SIC). In another study by Brown and Mason (2014), and based on Butchart's (1987), SIC defines high-technology-based firms. This definition was extended from the study by Glasson, Chadwick, and Smith (2006). High technology sectors are defined based on standard industry classification (SIC, 2003), and Table 2.3 lists the classifications.

Table 2.3: High-tech sectors by standard industrial classification

High Tech manufacturing activities	
11.1, 11.2	Energy
22.1, 22.3	Electronic Publishing
22.4, 33.1	Life sciences
25.24, 26.15, 26.82	Composites and other advanced materials
28.52	Precision engineering and Precision components
29 (all)	Machinery and equipment not classified elsewhere
30.01, 30.02	Computer equipment and machinery
31.1, 31.2, 31.4, 31.62	Electrical equipment
32.1,32.2,32.3	Electronic equipment and components
33.1,33.2,33.3,33.4	Medical and surgical equipment
34.10, 34.3	Transport equipment
35.3	Aerospace and related activities
36.5	Manufacture of Games and Toys
High-Tech Service Activities	
64.2	Telecommunications
72.2	Software development and consultancy

72.6	Web/Internet Services
72.1, 72.3, 72.4, 72.5,72.6	Other computer services
73.1	R&D (natural sciences & engineering)
74.2	Architectural & engineering activities
74.3	Technical testing & analysis
74.60/2	Security and related activities

Source: (Brown and Mason, 2014)

2.4.1 Definition of High-technology firms in this thesis

Researchers can find many high-technology definitions in the existing literature. Steenhuis and Bruijn (2006) identify four ways of defining high technology: (1) industry-based that is related to innovation; (2) firm-based, such as company level or entire industry; (3) product-based technology and R&D content; and (4) life cycle based like product development cycle that is important for economic development. The definition of high-technology firms, according to Mikovich (1987, pp 103–131), states that such firms “emphasise invention and innovation in their business strategy, deploy a significant percentage of their financial resources to R&D, employ a relatively high percentage of scientists and engineers in their workforce, and compete in worldwide, short life-cycle product markets”. This thesis defines high technology SMEs as “small and medium-sized firms with advanced knowledge and capabilities in technology, an educated workforce, and the ability to adapt quickly to fast-changing environments” (Crick and Spence, 2005, p. 168). The sectoral industry classification (SIC, 2007) was used to select the firms to participate in this study. The list of SIC classifications is in the appendix.

2.5 Definition of Innovation

Today, innovation is present in every sphere of economic and social life (Blattel-Mink, 2006; Fagerberg and Verspagen, 2009). Despite how popular innovation is, defining innovation could be challenging (see a review of definitions, e.g., Freeman (1982), Senge (1990), Rouse (1992), Garcia and Calantone (2002) and O’Sullivan and Dooley, 2009). What is responsible for this challenge is that innovation is studied in different contexts and disciplines (Adams, Bessant, & Phelps, 2006; Damanpour and

Schneider, 2006). Hence, the reason for the many definitions of innovation (Cooper, 1998; Zairi, 1995). The ideas and definitions of innovation are likely Schumpeter's most distinguished contributions to economics (Hanusch and Pyka, 2007). A common phenomenon in Schumpeter's treatise was the importance of innovation ("new combinations") in economic growth (Schumpeter, 1934, 1939). Schumpeter (1939) noted a sharp conceptual difference between invention and innovation, saying that an invention has not reached the market or been carried into practice, making it economically useless (Schumpeter, 1912). He defined invention as discovering new knowledge and the potential for solving economically irrelevant problems (Schumpeter, 1912). On the other hand, Innovation, he explained, is an invention that is exploited commercially and converted into economic value (Schumpeter, 1912). Schumpeter further defined innovation early on and distinguished five innovation types based on technical change, which are:

- 1) Creation of new products or improvements in existing products.
- 2) Introduction of new production methods.
- 3) The exploitation of new markets.
- 4) Use of new sources of raw materials and offering of products on the market; and
- 5) A new organisation of business or production (Schumpeter, 1934).

Also, the fundamental definitions and innovation types (occasionally alluded to as "innovation typology") are prescribed by the Organization for Economic Cooperation and Development (OECD) in a progression of handbooks, which is the source of regulations for collecting and usage of data on activities of innovation. According to OECD (1981), innovation is defined as: "... all those technical, businesses, scientific, and financial steps fundamental to the fruitful creation and marketing of improved or novel made products, the business utilisation of new or improved processes or the introduction of a new methodology to a social service".

Based on early innovation research, the OECD then developed three editions of the Oslo Manual (1992, 1997, and 2005), intending to harmonise and formalise studies on innovation across different countries. Oslo Manual (OECD, 2005) suggested the following definition. "Innovation is a novel or significantly improved product (good or service) introduced to the market or the introduction within a firm of a new or significantly improved process. Innovations come from the results of new technological developments, new combinations of existing technology, or the utilisation of external knowledge acquired by the firm. Innovations should be new to the firm concerned; for

product innovations, they do not necessarily have to be new to the market. For process innovations, the enterprise does not necessarily have to be the first to have introduced the process” (European Commission, 2005). The second edition of the Oslo Manual (OECD, 1997) focuses mainly on process and product or technological innovations, which are easier to define and measure. Still, the third edition of the Oslo Manual (OECD, 2005, p.46) defines non-technological innovations (marketing and organisational) besides technological innovations. Innovation is “the execution of a new or improved workplace organisation or external relations, a new marketing method, process or service, or a new organisational method in how business is conducted (OECD, 2005, p. 46). However, in a way, the OECD definition of innovation is more limiting than Schumpeter’s because entering new markets (mainly exporting) is not included in marketing innovation. In agreement with this limited understanding, firms' exports and innovations are treated as separate works of literature. Even though this is important, it is outside the scope of this thesis. By and large, two significant (theoretical) facets of innovation are likely recognised (Cooper, 1998; Gopalakrishnan and Damanpour, 1997): - innovation as a process that invigorates change (the result of spotlighting on innovation) and innovation as a discrete product, or object, or an event, portrayed by newness.

2.5.1 Types of Innovation

Understanding the types of innovation is vital as it is necessary for progress in identifying what constitutes innovation, which is central to the aim of this research (Edquist, 2001). Innovation contributes in many ways. For example, research shows a strong association between market performance and new products (Souder, Sherman, & Davies-Cooper, 1998; Tidd, 2006). New products help capture and maintain market shares and increase profitability in those markets. Innovations are heterogeneous, and a difference between different types of innovation is essential (Moller, 2007). According to the Oslo Manual (OECD, 2005), a contemporary definition widely adopted by governments and institutions, such as the Organisation for Economic Co-operation and Development (OECD), these highlighted different types of innovation. These anchors on the four main types of Innovation (OECD/Eurostat, 2005). The literature in this area examines the differences between the four types of innovation. The second aspect of the literature focuses on innovation itself and

explains the different degrees of innovation's newness (Bessant and Tidd, 2007, 2013). The first aspect is defined below.

- Product innovation – a good or service that is new or significantly enhanced.
- Process innovation- a new or significantly improved production or delivery method.
- Marketing innovation is a new method involving significant changes in product design or packaging, product placement, promotion, or pricing.
- Organisational innovation is a new method in business practices, workplace organisation or external relations.

The second aspect is the degree of innovation or novelty (Incremental versus radical innovation). Typically, scholars refer to an incremental-radical dichotomy that captures the different poles of a continuum (Tidd, 2001). The degree of innovation is explained as the newness of the innovation, as innovation can be something simple like enhancing the performance of a product or introducing something new to the market. The degree of innovation is crucial since increasing the novelty of innovation can aid a company in expanding its competitive advantage and creating new markets (D'Alvano and Hidalgo, 2012; Meissner *et al.*, 2017). This aspect of innovation has different names used to address it, for example, regular, niche, revolutionary and architectural innovation (Abernathy and Clark, 1985), radical and incremental (Dewar and Dutton, 1986), and incremental, radical and breakthrough innovation (Chandy and Tellis, 1998). The names incremental and radical innovations are commonly adopted because they are the most established classifications (Subramaniam and Youndt, 2005).

Incremental Innovation is the enhancement or improvement of an existing product, process, or service (Tushman & Anderson, 1986). Though incremental innovation has no cutting-edge effects, it creates changes that could be financially valuable and improve an organisation's competitiveness (Tushman and Anderson, 1986; Christensen, 2013). Some incremental innovation outcomes that increasingly improve the existing product, process, or service sometimes result in radical innovation (Katz, 2003).

Radical innovation is the development of entirely new knowledge, ideas, or technology that has never been created before but is not very common (Leifer *et al.*, 2000; Alexander and Van Knippenberg, 2014). Radical innovation transforms the economics in the marketplace, displaces current products ('creative destruction') and sometimes creates new product types and divisions. Although not all innovation efforts have revolutionary effects and lead to cutting-edge commercial value, this innovation effort is termed incremental innovation. The importance of this definition and classification of innovation to this thesis indicates that innovation can occur in every area of an organisation's operation, which includes the processes, services or products delivered by an organisation that can bring different organisational competitiveness (Bessant and Tidd, 2007). Table 2.4 below shows some authors' definitions of the difference between incremental innovation and Radical innovation.

Table 2.4: Different definitions of the degree of innovation

Authors	Incremental Innovation	Radical Innovation
Tidd and Bessant (2009)	"Improved existing innovation."	"Do something different."
Cooper (1998)	"Enhanced and extend the underlying technology."	"Revolutionary alteration"
Damanpour (1991)	"Little departures from existing practices"	"Produce fundamental changes in the activities of an organisation and represent clear departures from existing practices."

2.5.2 Drivers of innovation in firms

The significance of innovation to the growth of a firm, survival (Greve, 2003; 2014 Nogueira *et al.*, 2018; Ugur & Vivarelli, 2021) and profitability (Roberts, 1999; Saunila *et al.*, 2014; Huang and Hou, 2019) is well-established in the literature. The study on the importance of innovation goes back to 1930 by Joseph Schumpeter. His research on innovation had a significant impact on the economy (Goffin & Mitchell, 2010).

Schumpeter (1950), regarding the significance of innovation in firms, says that innovation not only affects the current profit and output of the firms but also makes fundamental changes in the organisation's lives. Innovative companies are likely to survive, while companies that are not innovative are likely to die. Knowing the importance of innovation, what, then, are the factors that inspire or drive firms to be innovative? Goffin and Mitchell (2010) classify them into four primary drivers.

Technological advances are the first driver, which comprises using new technologies in products and activities (such as using RFID in logistics) and deploying said technologies, such as tracking parcels (Goffin and Mitchell, 2010). These technological advances can inspire a company to respond quickly to these advancements and deploy them in their products/services to stay ahead of competitors. The second driver that encourages companies to engage in innovation is customers changing their behaviour or changing age, and their behaviour and requirements demand innovation in companies. For instance, the young population of a country is a different market compared to an ageing population. The third driver for innovation is intensified competition. Formerly, companies had to deal with their local or national competitors.

Nevertheless, with the rising production costs and logistics, companies now must compete with international competitors. For example, companies in China can manufacture a product much cheaper than in Western countries and sell their products there. The fourth and last driver is the changing business environment. Changes in regulations and laws will impact the economy by opening new markets that are easier to access than the previous situation (trade groupings such as the European Union). Also, during an adverse economic situation, firms may decide to cut down on their investment in innovation (Goffin and Mitchell, 2010).

2.5.3 The Innovation Process

The word process means the steps taken to achieve a particular end. The process is a structured set of activities designed to produce a specified output for a specific market or customer (Davenport, 1993). Within the sphere of innovation and technology, process means how innovation develops, grows, and terminates over time. The idea of process is connected to a series of actions or steps SMEs take to

implement innovation successfully. In an organisation, those responsible for making decisions are managers. Thus, managers should shape their strategic view and preferred actions during this innovation process to achieve desired results (De Wit and Meyer, 2003).

Consequently, these innovation processes cannot attain a certain level of effectiveness if the managers do not make the right decisions. There are some actions that SMEs need to engage in as a medium for developing specific innovations. According to Rosenberg (1982), in his black-box model of innovation, Innovation occurs from resource input and output of innovation results with the introduction of the black-box model. Figure 2.1 below shows the model.



Figure 2.1 Black Box Model

Source: (Rosenberg, 1982)

This model is not too complex, and it has some ramifications for research on innovation. Firstly, innovation is the whole process from resource acquisition (input) to undergoing innovation processes (the black box) to generating innovation results (output). Secondly, innovation activity depends on resources channelled towards R&D activities. Thirdly, the more resources an organisation commits to R&D activities, the more the organisation creates new products and processes. Similarly, the firm's resources, such as the workers' skill base, experiences, knowledge, existing technology and information, linkages, and finances, enhance the innovation process's success (Lee *et al.*, 1997; Evangelista and Savona, 2003).

Innovation is a series of events, not certainly sequentially, resulting in successful process development or business models and new products. Also, Innovation is a way of generating commercially profitable results, and the different theoretical models developed resulted from understanding the innovation process (Godin, 2012). Earlier

models showed the significance of the internal firm mechanism as an antecedent of innovation. Later models moved to the merger of internal integration and external collaboration. Theoretical models are used to explain the innovation process, which, over the years, has taken more elements into account, thus becoming more complex. Therefore, the best innovation model of the innovation process would consist of detailed steps of actions that result in successful innovation outcomes in an efficient way (Godin, 2006).

In conclusion, there is indeed an innovation process that affects a firm's innovation outcome. To some degree, the difference in innovation performance of some firms can be explained by different innovation processes driven by their strategic orientation (Adams, Freitas, and Fontana, 2019; Oktavio *et al.*, 2019). The next section will examine the various models of innovation developed to understand the innovation process and facilitate innovation.

2.5.4 Innovation Models

The innovation model is a conceptual framework to guide the innovation process. It helps organisations to make decisions that lead to successful innovation results (Rothwell, 1992). The 'Technology Driven model' (Technology Push model) was developed in the 1950's and depends on the knowledge and technology that comes from research and development (R&D) (Sammarrà and Biggiero, 2008). The 'Need Pull' model is the second innovation model, and it depends on exploiting market knowledge as a source of innovation (Rothwell, 1992). The third coupling model depends on the innovation process's interaction between R&D, manufacturing, and marketing. For the first time, the fourth model, the 'integration model', identified innovation as a parallel process (Rothwell, 1992). In this fourth model, innovation results from the interaction between science, the marketplace, and organisational capabilities (Trott, 2002). The fifth innovation model is the 'system and networking' model, which stresses that IT-based networking accelerates the process of innovation. Table 2.5 summarises the six generations of the innovation model.

The open innovation model differs from the traditional innovation model, which views innovation as the outcome of an organisation's internal activities (e.g., R&D). Developments from earlier innovation models resulted in Open innovation. In earlier

innovation models, firms only used their internal resources and capabilities to innovate. The following section will examine closed and open innovation models in detail.

Table 2.5: Generation of innovation framework models

Model	Generation	Characteristics	Strengths	Weaknesses
Technology Push	First	Simple linear sequential process, emphasis on R&D and Science	Simple Radical innovation	Lack of feedback. No market attention, No networked interactions
Market Pull	Second	Simple linear sequential process, emphasis on marketing	Simple, Incremental Innovation	Lack of feedback. No technology research. No networked interactions, No technological instruments
Coupling	Third	Recognising interaction between different elements and feedback loops between them, emphasis on integrating R&D and marketing	Simple, Radical and incremental innovation Feedback between phases	No networked interactions yet No technological instruments
Interactive	Fourth	Combination of push and pull models, integration within firms, emphasis on external linkages	Actor networking Parallel phases	Complexity increment of reliability No technological instruments
Network	Fifth	Emphasis on knowledge accumulation and external linkages, systems integration and extensive networking	Pervasive innovation Use of sophisticated technology instruments Networking to pursue innovation	Complexity increment of reliability
Open	Sixth	Combining internal and external ideas and internal and external paths to market can advance the development of new technologies.	Internal and external ideas, as well as internal and external paths to market, can be combined.	Assumes capacity and willingness to collaborate and network. Risks of external collaboration

Source: Rothwell, 1994; Eleveens, 2010; O'Raghallaigh *et al.*, 2011

2.5.5 Closed Innovation

Closed innovation (CI) is when a firm executes innovation and R&D activities within internal structures while securing intellectual property from exploitation by external actors (Chesbrough, 2006, pp. 21, 172). Closed innovation is a form of 'vertical integration, a strategy that firms deploy to control their supply chains' (Chesbrough, 2006, pp. 21-30; Porter, 2004b, p. 300). The purpose of closed innovation is about in-house innovation activities and to guard any valuable knowledge from being stolen or misappropriated (Chesbrough, 2006, pp. 21, 172; Clausen *et al.*, 2013, p. 228; Dries *et al.*, 2014; Laursen and Salter, 2014; Frishammar *et al.*, 2015; Manzini *et al.*, 2017; Wadhwa *et al.*, 2017; Wang *et al.*, 2017). Closed innovation is useful for developing products inside the organisation (Pavitt, 1998; Clausen *et al.*, 2013), developing products aimed at underpinning a firm's competitive advantage (Manzini *et al.*, 2017; Wang *et al.*, 2017), and for developing complex and revolutionary products (Almirall and Casadesus-Masanell, 2010). Pavitt (1998) suggested that inclusive coordination between skilled workers within the organisation is an important determinant of innovation performance. Clausen *et al.* (2013) argued that 'closed exploration' concerns a company's in-house creative capacity, whereas 'closed exploitation' concerns a company's capability to advance and sustain in-house innovation capabilities. In-house innovation is especially vital for products that underline a company's advantage over competitors (Manzini *et al.*, 2017; Wang *et al.*, 2017).

In addition, Almirall and Casadesus-Masanell (2010) showed that closed innovation is essential for developing world-first and technically complex products. For instance, the Apple iPod was mainly created using closed innovation. There is intense competition in the marketplace, so there is a growing need to generate innovative results efficiently. However, there are limitations in a firm's capability, which is quite common in small firms (Chesbrough, 2003). Because of these hindrances, the resources available to an organisation are not enough to achieve the expected outcome of innovation. Alternatively, innovation results filtered by one firm can be commercialised successfully by other organisations (Chesbrough, 2003). The close innovation strategy may be inefficient in

making a firm compete. A specific firm does not achieve what is expected, as the internal resources needed to guarantee continuous development of technological processes, new products and services are insufficient. Instead, it is better to change strategy by partnering with external partners such as research institutes, academia, suppliers, stakeholders, and start-ups to overcome this problem, which somehow agrees with the fifth-generation process of innovation that emphasises the importance of networking externally. For this reason, open innovation was proposed against closed innovation (Chesbrough, 2003).

2.5.6 Open Innovation

Many scholars have studied Open Innovation (OI) and show prominently in the academic literature (Chesbrough, 2003; Lichtenthaler and Ernst, 2009; Slowinski and Sagal, 2010; Huizingh, 2011; Aslesen and Freel, 2012; Spithoven, Frantzen, and Clarysse, 2010; Vanhaverbeke, 2013; Wikhamn, 2013; Cheng and Huizingh, 2014; Chesbrough and Bogers, 2014; Dries *et al.*, 2014; Michelino *et al.*, 2015; Hochleitner, Arbussà, and Coenders, 2016; Alberti and Pizzurno, 2017; West and Bogers, 2017). Open innovation is explained as 'when a firm accesses external resources during innovation activities' (Chesbrough, 2006, pp. 43-49). Many scholars acknowledge Chesbrough as the inventor of open innovation but also view open innovation as a significant departure from previous work (Lichtenthaler and Ernst, 2009; Slowinski and Sagal, 2010; Spithoven, Frantzen, and Clarysse, 2010; Huang, 2011; Vanhaverbeke, 2013; Wikhamn, 2013; Dries *et al.*, 2014; Michelino *et al.*, 2015; Hochleitner *et al.*, 2016; Alberti and Pizzurno, 2017; West and Bogers, 2017). Although, some have suggested that Chesbrough's open innovation paradigm was not a radical innovation but rather an evolutionary collection of pre-existing ideas (Huizingh, 2011; Aslesen and Freel, 2012; Cheng and Huizingh, 2014). Previous scholarly works before Chesbrough include Allen (1983), Teece (1986), von Hippel (1988), Cohen and Leventhal (1990), Rothwell (1994), and Pavitt (1998). Allen (1983) suggested that the unrestricted, industry-wide exploitation of new ideas is a primary driver of innovation. Teece (1986) argued that the ownership of complementary assets is essential in determining which organisations benefit from an innovation. Von Hippel (1988, p. 76) argued that 'colleagues seeking informal advice from one another are drivers of innovation'. Cohen and Leventhal (1990) argued that the strength of internal

knowledge underpins the utilisation of external knowledge to benefit internal innovation. Rothwell (1994) argued that access to external knowledge can minimise the funding and time required to deliver new products to the marketplace. Pavitt (1998) said that comprehensive and deep coordination between internally skilled workers in different departments is crucial in determining innovation outcomes.

Open innovation has three other types. They are an outside-in 'Open' innovation model, which is the opening to external resources as an input. The other type is called inside-out 'Open' innovation, which is the outflow of under-utilized ideas and coupled model which combines the inbound and the outbound process: rather than sharing existing resources and expertise, organisations collaborate to create new knowledge and solutions (Chesbrough, 2003; Gassmann and Enkel, 2004; van de Vrande *et al.*, 2009; Dahlander and Gann, 2010; Lichtenthaler, 2010; Euchner, 2013; Wikhamn, 2013; Kobarg *et al.*, 2019; Zhu *et al.*, 2019). Open innovation has some importance; for instance, Aylen (2010) compared examples of open innovation and Closed Innovation in the cold-rolled strip steel industry and summarised that open innovation resulted in more innovative solutions that became the leading industry technology. Increase in the cost of new product development, in addition to the rate at which technology gets obsolete, have driven firms to avoid expensive internal R&D whenever possible (Chesbrough, 2007; Lichtenthaler and Ernst, 2009; Lee *et al.*, 2010; Getz and Kaitin, 2012; Pullen *et al.*, 2012; Cruz-González *et al.*, 2015).

Chesbrough (2007) argued that open innovation allows companies to acquire partially developed technologies and accelerate new product development. Lichtenthaler and Ernst (2009) noted that companies need open innovation to stay afloat rather than outcompete rivals. In the pharmaceutical sector, there is a clear demand for open innovation and quicker new product development where firms face stiff competition, high R&D costs, and reduced patent service life (Getz and Kaitin, 2012). However, open innovation is not guaranteed to have lower R&D costs as broad external searches are relatively low-cost and important for incremental innovations. In contrast, deep external searches incur high costs but are essential for radical innovations (Cruz-González *et al.*, 2015). Figure 2.2 and Table 2.7 shows the difference between closed and open innovation.

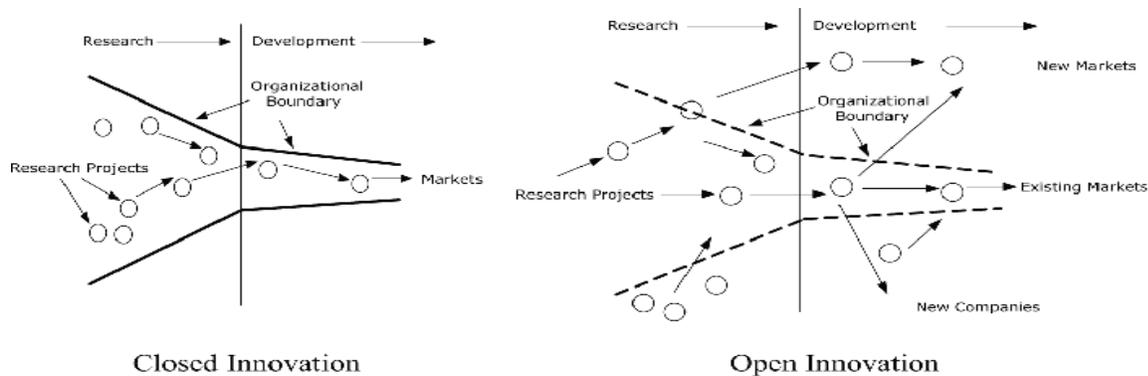


Figure 2.2 Closed and Open Innovation

Source (Chesbrough, 2003)

Table 2.6: Contrast between closed and open innovation

Closed Innovation	Open Innovation
Intelligent people in the same fieldwork with us.	Not all smart people work with us. We try to work with smart people inside and outside the company.
To make a profit from R&D, we must discover it and ship it to ourselves	External R&D can create significant value; internal R&D is needed to claim some portion of that value
If we discover it ourselves, we will ship it to market first	We do not have to originate the research to profit from it.
The company that gets an innovation to market first will win	Building a better business model is better than getting to market first.
If we create the most and the best ideas in the industry, we will win	We will win if we use internal and external ideas best.
We should control our IP so that our competitors do not profit from our ideas.	We should profit from others' use of our IP, and we should buy others.
IP whenever it advances our business model.	

Source: (Chesbrough, 2003)

As Table 2.6 shows, the main difference between the closed innovation model and the open innovation model is in the utilisation of R&D capabilities and both internal and external ideas in addition to existing and new markets to enhance a firm's technological capabilities. In an open innovation model, firms partnering share their resources to improve how the involved firms access the resource input and improve the chances of generating innovation outcomes. Conversely, sharing innovation results means commercialising innovation results would likely be successful (Chesbrough, 2003). On these two bases, the profit and risk of R&D activities are divided between the partnering firms, thereby minimising the opportunity cost of the closed innovation model and making R&D activities more efficient. Therefore, the open innovation model is seen as more efficient than the closed innovation model as open innovation projects are increasingly adopted by SMEs for financial reasons (Chesbrough, 2003).

Moreover, the strategic orientation of SMEs, if they engage in open innovation such as collaboration with third parties and cooperation, can result in innovative performance for their firm (Cheng and Huizingh, 2014). Also, organisations cannot possess all the capabilities and knowledge to create desired innovations (Cassiman and Veugelers, 2006; Chesbrough, 2007; Lichtenthaler and Lichtenthaler, 2009). Nevertheless, they can obtain knowledge from third parties (outside-in activities). Businesses search among competitors and customers to increase their understanding of the marketplace and among research institutes and universities to explore new directions. The acquired knowledge allows firms to develop new offerings based on new aggregations of technologies and markets and can thus result in more excellent innovation performance. Figure 2.3 and Figure 2.4 below show how their representation.

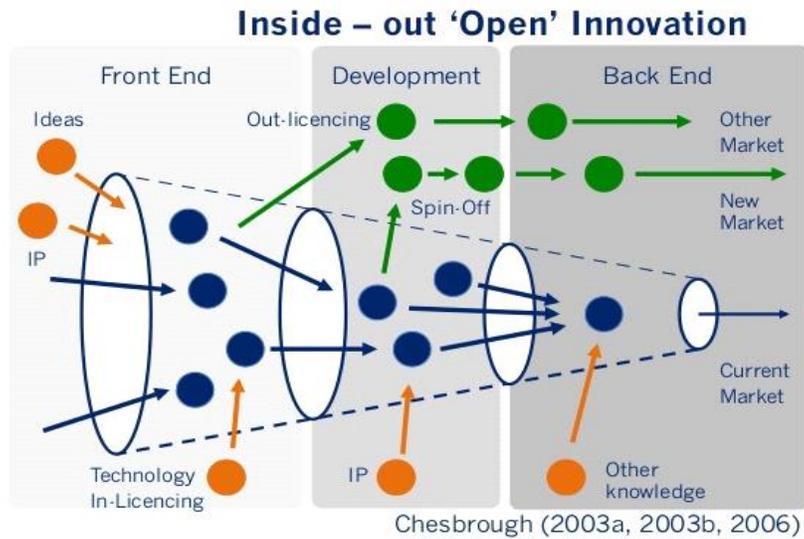


Figure 2.3 Inside-out Open Innovation

Source (Chesbrough, 2006)

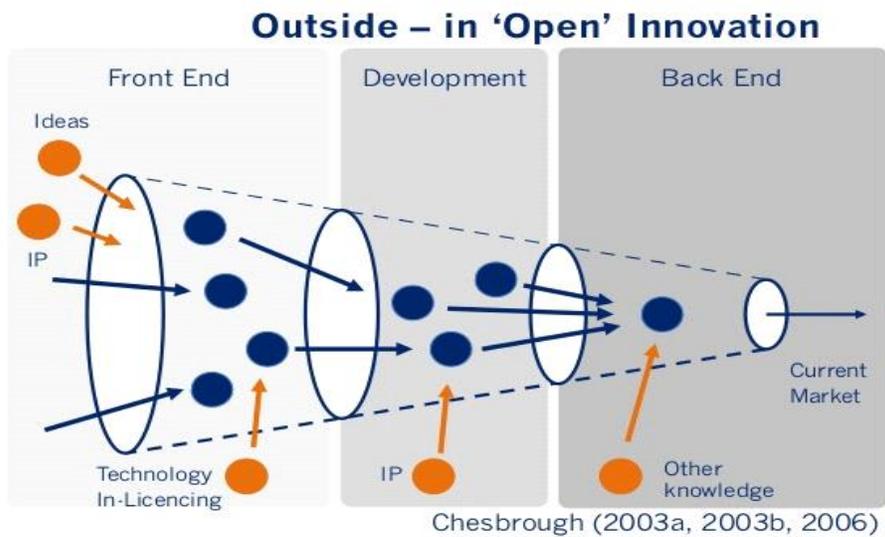


Figure 2.4 Outside-In Open Innovation

Source: (Chesbrough, 2006)

These models show how organisations innovate or have innovated in the past. The following section will briefly look at drivers of open innovation, which is vital to an organisation's development and sustenance. All the models show that one of the most critical drivers of innovation is acquiring and implementing new knowledge and other vital resources.

2.5.7 Summary

This chapter examined the role and importance of small businesses, the definition of a small business, a brief evolution and debate. Several sources, including the Bolton Committee Report, the European Commission and the Department of Trade and Industry, put forward the definition of small business. The UK Definition of small and medium-sized enterprises (SMEs) is reviewed. This chapter also investigated SMEs' related data such as numbers of Businesses, employment, and turnover share by size band in the United Kingdom. These investigations demonstrated how important SMEs are to the British economy. They established the proportion of their contribution to the British economy regarding job and economic growth and how SMEs stimulate innovation in the UK. Finally, there is an examination of the definition of high-tech SMEs, the importance of firms being innovative, the definition of innovation, innovation types, and the different innovation models.

CHAPTER 3: LITERATURE REVIEW

3.1 Introduction

Innovation is a stimulant for developing nations' economies. Innovation supplies firms with the ability to create a long-term competitive advantage necessary in today's turbulent business environment and is the mainstay of corporate survival and growth (Schumpeter, 1934; Zahra and Covin, 1994). Innovation is a significant factor in developing new products, processes, and organisations (Gërguri-Rashiti *et al.*, 2017). A firm's internal technology policy shows its innovative commitment to innovation. Commitments to technology and innovation can result in a firm achieving a competitive advantage (Hitt *et al.*, 1990; Powell and Dent-Micallef, 1997; Bhatt and Grover, 2005). Thus, a firm's technology orientation significantly affects its ability to innovate and is seen as a vehicle for a competitive advantage, which can lead to better firm performance (Humphreys *et al.*, 2005; Rhee *et al.*, 2020). Technology orientation represents the most crucial element for acquiring and developing novel technologies and integrating them into the firm innovation activities with firm resources to achieve innovation performance. The proceeding sections will examine the literature on technological orientation and innovation performance as a theoretical basis for this thesis. This chapter also reviewed the strategic firm resources selected to influence the innovation performance of tech-oriented SMEs. The chapter then concludes with a summary of the chapter.

3.2 Technology Orientation

In today's changing business environments, firms must develop organisational behaviours to manage innovation and differentiate themselves from competitors to gain more business opportunities and long-term competitive advantage. As firms compete in a dynamic environment and are usually scarce of vital resources, they need a strategic orientation(s) to stay ahead of the competition. Strategic orientations are principles that influence activities to generate behaviours that guarantee survival and performance (Grinstein, 2008; Hakala, 2011). Strategic orientations such as learning orientation, entrepreneurial orientation, market orientation, and customer orientation, as well as their

role in influencing a firm's survival and performance, are commonly investigated (Deshpande *et al.*, 2013). Technology orientation (TO) is another orientation whose role in a firm's performance needs further research, especially in high-tech SMEs (Noble, Sinha, and Kumar, 2002; Hakala, 2011; Ramírez-Solis, Llonch-Andreu, and Malpica-Romero, 2022). The fundamental concept of TO is that long-term performance is achieved through new products, services and technological solutions (Hamel and Prahalad, 1991; Gatignon and Xuereb, 1997; Grinstein, 2008)

Salavou, Baltas, and Lioukas (2004) explained technology orientation as a key driver stimulating innovation and developing new products and services. It is crucial in facilitating a firm's performance (Zhou *et al.*, 2005; Hortinha *et al.*, 2011). Technology orientation can enable small firms, especially start-ups, to overcome resource scarcity by leveraging technological capability and flexibility (Hakala and Kohtamaki, 2011; Hortinha *et al.*, 2011). Technology orientation allows a firm to be proactive in research and development, accumulate new technologies, and integrate cutting-edge technology into its latest products (Voss and Voss, 2000; Zhou *et al.*, 2005). Grinstein (2008) argues that technology-oriented firms are inclined to use or introduce new technologies, innovations or products. Gatignon and Xuereb (1997, p. 78) define technology orientation as " the use of sophisticated technologies in new product development, the rapid integration of new technologies, and proactively developing new technologies and creating new product ideas." ...

This thesis adopts the definition of TO by Gatignon and Xuereb (1997). According to Gatignon and Xuereb (1997), TO emphasises a firm's performance, which is determined by the technological positioning that steers its activities toward technological breakthroughs and product innovation. Product innovation stresses the critical role of technology in gathering information and new product development (Goedhuys and Veugelers, 2012). Herhausen (2016) notes that an organisation needs to use technology orientation to build a solution to deal with the changing demands of customers. Empirical evidence also shows that technology orientation within an entrepreneurial firm can deliver more benefits to consumers and facilitate the firm's capacity to respond to the identification of market opportunities, demand uncertainty, and competitive intensity

(Salavou, Baltas, and Lioukas, 2004; Zhou *et al.*, 2005; Hall and Rosson, 2006). Hakala (2011) showed that TO enhances new products and business performance.

Firms may achieve sustainable competitive advantage in dynamic markets through Organisational and technological capabilities that allow them to monitor changes in the market and create, discover, and exploit new opportunities which match environmental requirements ahead of their rivals (Jantunen *et al.*, 2005; Zahra, Neubaum, and Larrañeta, 2007). Technology orientation is a critical organisational capability in creating new products (Salavou, 2005), and a tech-oriented SME could achieve a source of competitive advantage in highly volatile markets if it exploits its technological capabilities (Halac, 2015; Yarahmadi *et al.*, 2015). The importance of a technology orientation is the increase of R&D strategic partnerships such as the IBM-Apple-Motorola partnership for Power PC or the GM-Toyota partnership, whose aim is to share competencies and cost for the creation of innovative products (e.g., Wind and Mahajan, 1997). Past research has examined the role of TO in new product development and innovation. Some scholars show a positive influence, while some research has not consistently identified positive effects; thereby, the results of the effect of technology orientation are still somewhat fragmented.

In a study by Caroline Derozier (2003) on the role of market orientation, technology orientation, and inter-functional coordination in new product development, 60 managers participated, and the findings showed that technology orientation plays a significant role in promoting marketing creativity and business performance. Another study by Salavou (2005) examined whether technology orientations influence product innovativeness in SMEs. One hundred fifty manufacturing SMEs, which comprise Greece's food and beverages and textiles industries, were chosen as participants. The empirical results indicate that technological orientation is more crucial than customer orientation when it comes to communicating a product's novelty to consumers. This improves the likelihood that the company will create a new product that goes beyond their consuming habits and experiences. Furthermore, Zhou *et al.* (2005) investigated the effects of strategic orientations on technology and market-based breakthrough innovations in 350 firms in China. The findings showed that technology orientation benefits technology-based

innovations but does not impact market-based innovations. Rezazadeh, Karami, and Karami (2016) also investigated the effect of technology orientation on firm performance and the mediating role of dynamic capabilities in 154 small to medium-sized enterprises (SMEs) located in Science Parks in Iran. The results support that a firm's technology orientation is associated with performance, and a firm's dynamic capabilities positively mediate the relationship between technology orientation and firm performance.

Similarly, Alerasoul *et al.* (2022) investigated the synergistic impact of market and technology orientations on sustainable innovation performance: evidence from manufacturing firms in 373 Italian manufacturing firms. The findings showed that the synergistic co-alignment of technology orientation with both dimensions of Market orientation (i.e., responsive and proactive) can help firms increase their performance regarding sustainable innovation. However, the role of technology orientation as one of the essential types of strategic orientation is still somewhat inconclusive (Hakala and Kohtamaki, 2011; Rezazadeh, Karami, and Karami, 2016). For instance, Hakala and Kohtamki (2011) found that the position of technological orientation as one of the most essential aspects of strategic orientation is still relatively fragmented and needs more investigation. Some findings also found that not all firms with high levels of TO have achieved innovation performance (Lee *et al.*, 2015; Hunt, 2016). Hence, exploring the mediators and moderators in the relationship between TO and innovation performance is suggested (Chen and Lien, 2013). In addition, most research on technology orientation is conducted in large firms (Salavou, 2005; Zhou *et al.*, 2005; Hakala and Kohtamki, 2011; Yarahmadi *et al.*, 2015). Hence, the function and contribution of technology orientation in SMEs are still under-theorized. Additionally, the mechanism through which technology orientation is converted to innovation performance is not well investigated, mainly how technology-oriented SMEs manage and orchestrate internally developed and externally acquired heterogeneous strategic firm resources to integrate into their innovation process to achieve innovation performance (Carnes *et al.*, 2017). See table 3.1. shows some past literature on technology orientation and the theories used with their findings.

Table 3.1 Past Literature on Technology Orientation

Authors, Year	Sample	Theories	Focus	Contributions/Findings
Gatignon and Xuereb (1997)	393 Managers across different firms	Market Orientation Theory, Diffusion Theory	Strategic orientation of the firm and new product performance.	The strategic orientation of a firm (customer, competitive, technological orientation determines product innovation performance
Caroline Derozier (2003)	Survey of 640 American firms	Market Orientation theory	Marketing creativity in new product development: the role of market orientation, technology orientation, and inter-functional coordination.	Technology orientation plays a significant role in promoting marketing creativity and business performance.
Salavou, (2005)	150 Manufacturing SMEs in Greece	Resource Based Theory	Do customer and technology orientations influence product innovativeness in SMEs? Some new evidence from Greece.	Technology orientation influences product innovativeness in SMEs
Zhou <i>et al</i> , (2005)	Survey of 350 firms in China	competitive force perspective and the resource-based view (RBV),	The effects of strategic orientations on technology and market-based breakthrough innovations.	A technology orientation benefits technology-based innovations but does not impact market-based innovations.
Hakala and Kohtamaki, (2011)	1,283 firms from Finland database	Organisational learning	Configurations of entrepreneurial-customer-and technology orientation: Differences in learning and performance of software companies	Utilising multiple strategic orientations simultaneously (e.g., consumer orientation, technology orientation, entrepreneurial

				orientation) increases learning capability.
Al-Ansari, (2013).	Survey data from 200 Dubai SMEs	Innovation theory Customer Value-based Theory		Technology orientation influences innovation, and there is a relationship between technology orientation and firm performance being mediated by innovation.
Liu, J., and Su, J. (2014)	A sequential qualitative–quantitative, mixed method was used with a single case study and a questionnaire survey	Innovation theory	Market orientation, technology orientation and product innovation success: Insights from CoPS.	A technology orientation is beneficial to the success of high-tech complex products and systems innovation but has no impact on the success of low-tech complex products and systems innovation.
Halac, (2015).	Two-step field survey with 147 firms	Learning Theory, Resource-Based View	Multidimensional construct of technology orientation	The four-dimensional construct of technology orientation (top management capabilities, technology capability, commitment to learning, commitment to change) influences firm performance.
Lee, Dedahanov, and Rhee, (2015)	352 organisations in South Korea	N/A	Moderating the role of external networks and mediating the effect of innovation performance on the relationship between technology orientation and firm performance	External networks appear to have a positive moderating effect on the relationship between technology orientation and innovation performance, and innovation

				performance mediates the associations between technology orientation and financial performance
Rezazadeh, Karami, and Karami, (2016),	Quantitative Survey with 141 SMEs in Iran	Dynamic Capability	Technology orientation, dynamic capabilities and SME performance	The results support that a firm's technology orientation is associated with performance, and a firm's dynamic capabilities positively mediate the relationship between technology orientation and firm performance.
Yousaf <i>et al.</i> , 2020	The quantitative approach was adopted in software houses in 2 big cities in Pakistan.	N/A	Does technology orientation predict firm performance through firm innovativeness?	Technology orientation predicts firm performance (FP), and financial innovation predicts the relationship between TO and FP
Alerasoul <i>et al.</i> (2022)	373 Italian manufacturing firms.	Resource-based view (RBV), stakeholder theory	The synergistic impact of market and technology orientations on sustainable innovation performance: evidence from manufacturing firms	Synergistic co-alignment of Technology orientation with both dimensions of Market orientation (i.e., responsiveness and proactiveness) can help firms increase their performance regarding sustainable innovation.
Nassani <i>et al.</i> , (2023)	428 Electronic Firms	Resource-based view (RBV) theory	Does Technology Orientation Determine Innovation Performance	Results showed that technology orientation is a major predictor of

			through Digital Innovation? A Glimpse of the Electronic Industry in the Digital Economy.	innovation performance in the electronic industry. Also, results showed that digital innovation bridges technology orientation and innovation performance.
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3.3 Innovation Performance

Businesses must constantly adapt to today's unstable and uncertain business environment to thrive. Innovation to deal with volatility is facilitated by new processes, ideas, goods and strategies (Hassan, 2018). Innovation is important for strategy development because it allows businesses to show their competitiveness by differentiating their products, increasing efficiency, breaking into new markets, growing their market share (Günday *et al.*, 2008; Ferreira *et al.*, 2017). Greco, Grimaldi, and Cricelli (2016) argued that firms must constantly innovate to maintain a competitive edge. Organizations have started to improve their innovative performance in the competitive business environment to achieve great success and stay competitive in competitive marketplaces (Greco, Grimaldi, and Cricelli, 2016). Similarly, one of the primary traits of entrepreneurial behavior that is somewhat related to small and medium-sized businesses is innovation (Oke *et al.*, 2007). According to Ferreira, Fernandes, and Ratten (2017), SMEs increasingly turn to innovation to grow, improve, and sustain their competitiveness. To determine whether an organization is innovative and how to measure it, Çömlek *et al.* (2012) and Ghasemzadeh *et al.* (2019) contend that innovation performance needs to be defined. Innovation performance is the process of applying new ideas and creativity to build products, processes, and procedures that enhance the performance, utility, and relevance of goods and services (Hanifah *et al.*, 2020). In a similar vein, innovative performance describes an organization's capacity to provide the market with novel items in addition to short-term financial success.

Innovation performance is the organizational outcome where inventions are commercialized and brought to the market. According to Çömlek *et al.* (2012), the launch of a new product might, therefore, be considered a sign of innovative performance. In a similar vein, innovation performance is a compilation of the entire achievements of the organization as a result of the development and renovation activities carried out, taking into account many facets of innovation, such as marketing, goods, organizational structure, procedures, etc. Building a composite based on many performance indicators, including new patents, new products, new initiatives, new practices, and new

organizational procedures, is known as innovative performance (Hagedoorn and Cloudt, 2003). Innovation performance was defined by Gunawan, Jacob, and Duysters (2016) as the quantity of innovative products that the company brought to market. According to Anggadwita and Mustafid (2014), innovation performance measures the firm's ability to develop innovation, which comprises the firm's activities and the effect of innovation. Further, innovation performance is a blend of indicators used to personify innovation objectives that are general and specific. Specific objectives comprise creating working conditions, addressing social challenges, and meeting new regulations (Bloch and Bugge, 2013).

Additionally, Smith (1992, 2006) noted innovation performance as the share of sales of newly developed products and services. Similarly, (OECD/Eurostat, 2005; Prajogo and Sohal, 2006 Roberts, 1988, 2007) said innovation performance is measured by product and process innovations. Ramli *et al.* (2017) explained innovation performance as the effect of innovation on organisational performance in terms of service delivery, confidence, and satisfaction. In this thesis, innovation performance is defined as the development of new and improvement of products, services and processes. Numerous studies have examined the determinants and consequences of innovation performance. For instance, scholars examined public funding (Albors Garrigos, Hervas-Oliver, and Rodriguez, 2011), search strategies (Henttonen, Ritala & Jauhiainen *et al.*, 2011), competition (Geroski, 1990; Blundell *et al.*, 1995; Galdon-Sanchez and Schmitz, 2002), Competition alignment (Ritala, 2012), turbulence (Lumpkin and Dess, 2001; Hult *et al.*, 2004; Atuahene-Gima *et al.*, 2006), Inbound open innovation activities (Parida, Westerberg, and Frishammar, 2012) as the determinants of innovation performance. Regarding the consequences, some studies looked at financial performance (Hollenstein, 2003) as an innovation performance outcome. Additionally, some studies have employed R&D intensity, process improvements, new product development/performance, and the number of patents as measures of innovation performance (Hult and Ketchen, 2001; Hult *et al.*, 2004). In the context of investigating SMEs' innovation performance, previous studies in this field have used methods and performance dimensions to examine the innovation performance of SMEs. Some results on innovation performance are shown in the table below.

Table 3.2: Overview of selected articles on innovation performance

Authors	Performance Indicators	Sample or Society
Al-Ansari, Altalib and Sardoh, (2013)	Number of new products, services, processes, or organisation/management systems	200 Dubai SMEs
Hanifah <i>et al</i> , (2022)	New product, service, or technological process	140 Bumiputera SMEs in Malaysia
Çömlek <i>et al</i> , (2012)	New product introductions	199 middle and senior managers in the metalworking industry in the Marmara region of Turkey
Adams, Freitas, and Fontana, (2019)	Successful commercialisation of new products	1603 French manufacturing firms
Hamalumba and Kesamang, (2019)	Number of new products, services, and processes	321 Small service firms in Botswana

3.4 Factors that drive Innovation Performance

Innovation performance is a vital element for the success and growth of firms because it engenders efficiency, quality, competitive position, and productivity (Shahzad *et al.*, 2019). High levels of innovation have a favorable impact on high performance, according to studies like Tajeddini, Martin, and Altinay (2020), Mattsson and Orfila-Sintes (2014), and Rosenbusch, Brinckmann, and Bausch (2011). An innovative company can leverage innovation to attain greatness by offering customers distinctive goods and services. Innovation performance boosts competitiveness and sustains the organization's performance through ongoing product, process, and service development (Lazonick and Prencipe, 2005; Bagno *et al.*, 2017; Waheed *et al.*, 2019; Olokundun *et al.*, 2018). Jackson (2020) argued that innovation performance can significantly enhance economic development through "creative destruction". Schumpeter (1934) regarded "creative destruction" as the basis of competitive advantage. According to Schumpeter (1934), firm success is not necessarily associated with industry structure or market power but rather is the result of innovation and new technologies, which are critical in influencing the dynamics of the external environment and competition. Since innovative performance has become the crucial growth driver, organisations should understand the factors contributing to innovation performance.

There is widespread knowledge among researchers and practitioners that innovation is vital for organisations looking to gain market share and survive long term (Molina-Catillo and Munuera-Aleman, 2009; Anderson, Potočnik, & Zhou, 2014). Barney (1991) argued that organisations can compete in dynamic business environments through tangible and intangible firm resources that are possibly rare, valuable, inimitable and non-substitutable. Since "innovation is a vehicle of economic growth and a potential source of firm-level performance heterogeneity" (Grigoriou and Rothaermel, 2014, p.587), examining the factors that influence innovation performance should be a scholarly and managerial issue. However, the effect of strategic firm resources on innovation performance has received some research attention (Urgal, Quintás, & Arévalo-Tomé, 2013; Laosirihongthong, Prajogo, and Adebajo, 2014; Rosenzweig & Grinstein, 2016). Demirkan, 2018), the roles

of managers in how to structure, bundle and leverage firm resources and capabilities have not received much attention in empirical studies (Sirmon *et al.*, 2007; Li and Jia, 2018; Bittencourt, dos Santos, and Mignoni, 2021). Thus, this thesis aims to investigate the drivers of innovation performance within the context of the resource-based view of the firm and resource orchestration theory.

3.5 The role of strategic firm resources

In high-tech firms, resources are significant to be acquired or developed (Hage and Alter, 1997). Some scholars believe that internal research and development is the most effective means to obtain and develop resources (Penrose, 1959; Cohendet, Parmentier, & Simon, 2017). R&D activities are suitable for staying up to date with competitors and imitating the latest technology in the market, as well as developing product and process innovations (Cohen and Levinthal, 1990; Hsu, Lien, and Chen, 2015; Hottenrott and Lopes-Bento, 2016). Increased level of R&D activities in a firm can propel firms to develop heterogeneous resources and exploit more technological opportunities, and this could result in an increased level of innovation and firm performance (Free, 2003; Savrul and Incekara, 2015; Hottenrott and Lopes-Bento, 2016). Further, the skills of employees are an essential asset in the innovation process, as a large part of an organisation's knowledge base resides in its employees (Veugelers, 1997; Hadjimanolis, 2000; Free, 2005; Tether *et al.*, 2005; Rampa and Agogu e, 2021).

Large firms have different experiences, knowledge, and skills, and more employees engaging in R&D could enhance their performance level. Hatch and Dyer (2004) suggest that human resources are strategically vital in semiconductor manufacturing as they personify firm-specific knowledge and that firms that use effective human resources selection, training, and deployment processes encourage learning to enjoy sustainable competitive advantage (Hitt *et al.*, 2001). Therefore, it is vital to create innovative competencies on the market. Internal resources such as employees' skills and knowledge enable firms to accumulate capabilities (Rominj and Albaldejo, 2002). The capability base of a firm is enhanced through internal learning by investing in R&D, making minor changes to products, processes, in-house staff development and so on. Highly trained employees

seem to have an advantage in developing, adopting, and implementing new technologies (Freel, 2005; Gospel, 1991). Further, R&D departments can give external partners an identifiable and recognisable unit within an organisation, enabling more efficient knowledge transfer, significant innovation, and performance. For SMEs who face specific problems in establishing external partnerships, their ability to access external knowledge depends on their in-house employment of qualified scientists, technical specialists, and engineers (Freel, 2005; Rampa and Agogué, 2021).

Moreover, the capacity to go for it alone increases a firm's bargaining power in negotiating with outside partners and acquiring resources from both internal and external sources. External resource acquisition also impacts firm innovation performance. It can be assessed through externally available information (Yam *et al.*, 2011), external R&D (Pellegrino *et al.*, 2012), acquiring domestic technology for innovation activities (Li, 2011), formal technology collaborations and networking with suppliers, universities (Protogerou *et al.*, 2017) and external financial sources such as access to banks, venture funds, government support (Pellegrino *et al.*, 2012; Kim, Yeom, and Ko, 2020; Cowling, Liu, and Zhang, 2021; Zhao, Xiao, and

Zhang, 2021). While the role of technology and financial resources on innovation performance has been examined in previous studies (Julienti Abu Bakar and Ahmad, 2010; Parida and Örtqvist, 2015; Cowling, Liu and Zhang, 2021), it is necessary to explore how managers orchestrate these strategic resources in their innovative activities to achieve innovation performance.

According to the RBV, a firm's essence is a collection of heterogeneous resources, and the process of converting firm resources into innovation performance does not occur naturally (Teece and Pisano, 2003). Factors such as organizational culture, organizational structure, and organizational strategy will influence the transformation process, and innovation leads to the direction that can affect the accumulation of innovation resources and capabilities within the firm to impact firm innovation performance (Gruner and Homburg, 2000). RBV suggests that a firm possesses a valuable bundle of resources and capabilities (Wernerfelt, 1984), and some resources and capabilities can better

impact firm performance (Nath et al., 2010; Ferreira and Fernandes, 2017). Knowledge and information are increasingly viewed as valuable resources (Chen *et al.*, 2011). The firm's survival and sustainable development depend on its resources and capabilities to create competitive advantages (Peteraf, 1993, Sirmon *et al.*, 2011). Thus, RBV considers that firms must put their resources and capabilities to best use and develop their new resources and capabilities to maintain and develop more competitive advantages (Peteraf, 1993; Nath *et al.*, 2010). We adopt the resource-based view and resource orchestration framework to analyze the effect of external and internal resources on high-tech SME innovation performance.

Some resource management studies argue that identifying the resources valuable to a firm provides the first step towards the successful management of these resources (Sirmon et al., 2008; Denford, 2013; Carayannis *et al.*, 2014; Battisti and Deakins, 2017; Pinho and Ferreira, 2017). Some of the strategic firm resources that have been identified and studied within the context of high-tech SMEs include R&D resources (Yang, Bossink, and Peverelli, 2017), skilled employees (Yang, Bossink, and Peverelli, 2017; Buenechea-Elberdin, Kianto, and Sáenz, 2018). Customer relationship and technological capabilities (Tzokas, et al., 2015), political and market legitimacy (Liu and Wang, 2022), R&D personnel and R&D expenditure (Zhu, Wang, and Wang, 2019), government subsidies (Zhu, Wang, and Wang, 2019), intellectual capital (Buenechea-Elberdin, Kianto, and Sáenz, 2018), financial resources (Demirkan, 2018). However, there are no studies that have considered the mediating role of the availability of technological resources, the availability of financial resources, network capability and degree of openness in small tech-oriented high-tech firms (Satta et al., 2016; Lecerf and Omrani, 2020; Tong and Serrasqueiro, 2020; Atzmon, Vanderstraeten, and Albers, 2022; Daniel, 2023; Löfsten, Isaksson, and Rannikko, 2023). To address this knowledge gap. Thus, this study examines the mediating role of the availability of strategic firm resources and resource orchestration between TO and innovation performance.

3.5.1 Technological Resources

Technological resources are strategic firm resources that create, manipulate, store and disseminate information. Technological resources enable human beings to work easier and faster to achieve a goal (Barney, 1991). Technological resources comprise two categories: tangible technological resources such as tools, machinery, and physical elements applied to a physical task. On the contrary, intangible technological resources are about what cannot be touched, such as software, knowledge, patents, intellectual properties, or the Internet. The strategic deployment of technology is essential in converting innovation into enhanced firm performance (e.g., Sakaguchi, Nicovich, and Dibrell, 2004; Ray *et al.*, 2005). A direct relationship between the deployment of technology and innovation performance was established by (Usai *et al.*, 2021; Chege, Wang and Suntu, 2020; Tajudeen *et al.*, 2022). Bharadwaj (2000) and Grover (2003) found that high technology firms, i.e., those that invest a lot in technology, perform better than rivals who do not invest in the same way. These results suggest that technology offers firms competitive competency, which aids firms in differentiating themselves in the marketplace through innovation. The pursuit of firm performance and competitive advantage against competitors, as a significant task of small firms, has become one of the beliefs of contemporary management theories (Teece *et al.*, 1997). Technological innovation is believed to generate such an advantage (Tidd, Bessant, and Pavitt, 2002; Wang, 2019; Chege, Wang, and Suntu, 2020). Therefore, the role of technological resources for small high-tech SMEs cannot be understated; hence, the reason for examining their role in the innovation performance of technology-oriented firms (Christensen, 2013).

Despite their prominence as critical constructs in the literature, possible relationships among technology, use of technology and innovation performance have not been the subject of extensive investigation in high-tech SMEs (Fichman, 2001; Carnes *et al.*, 2017; Usai *et al.*, 2021). Das, Zahra, and Warkentin (1991) argued that the practical application of technology should enable organisations to respond more appropriately to their environment and receive in addition to processing information more efficiently (Hanson, 1999), therefore facilitating competitive advantage (Porter and Millar, 1985; Barney, 1991;

Ray *et al.*, 2005). Consequently, firms often invest substantial resources in technological assets (e.g., computer software, computer hardware and personnel) (Krishnan and Sriram, 2000). Over time, firms that invest more than their competitors in technology may achieve a competitive advantage (Bharadwaj, 2000). However, there is not a substantial body of theory-driven empirical work that demonstrates how the actual orchestration of technological resources by firm managers interacts to enhance innovation performance (see Srivardhana and Pawlowski, 2007; Wang *et al.*, 2012; Camison-Haba *et al.*, 2019). The purpose of the present study is to contribute to closing this gap.

3.5.2 Financial Resources

Financial resources are the funds and assets that finance an organisation's activities and investments. In simple terms, financial resources are the monies that keep a business operating. Financially endowed firms are more likely to take advantage of new opportunities than those with financial limitations and invest more in research and innovation. Scholars have widely debated the effect of financial resources as a factor for firms to invest in innovative activities (Hubbard, 1998; Hall *et al.*, 2016). Financial resources are important for high-tech firms as they require investments for acquiring skilled staff, licenses, technologies, research facilities, and additional equipment (Gulati *et al.*, 2000; Patzelt *et al.*, 2008). In this vein, scholars debate on the impact of internal and external financial resources on R&D activities (Himmelberg and Petersen, 1994; Mulkay *et al.*, 2001), propensity toward innovation (Kochhar and David, 1996; Patzelt *et al.*, 2008), and new product development (Svensson, 2007) in high-tech firms. Financial resource commitments in R&D activities facilitate high-tech SMEs to surmount challenges in the new product development process (Shan *et al.*, 2016). Given that small firms operate in a competitive and dynamic environment (Hasan *et al.*, Boh *et al.*, 2020), they will undoubtedly encounter risk and uncertainty. Particularly, high-tech SMEs face high organisational risk, where the support of financial resources is limited in comparison to big firms (Zhu *et al.*, 2019; Guo *et al.*, 2019). For this reason, the availability of financial resources and its role in small high-tech firm's innovation performance in the UK is going to be examined.

Moreover, financing R&D and innovative projects becomes more problematic because of the intangible nature of innovation outputs (Ughetto, 2008), the problem of estimating future cash flows, and critical information asymmetries (Carpenter and Petersen, 2002). This matter appears even more problematic in high-tech firms, which require enormous investments to acquire skilled staff, research facilities, technologies by third parties, and additional equipment (Gulati, Nohria & Zaheer, 2000; Patzelt *et al.*, 2008). Resource-based theories of innovation spotlight the importance of an organisation's levels of financial Resources for their engagement in research and development (R&D). (Jissink, Schweitzer, and Rohrbeck, 2019; Gonzalez-Bravo, Lopez-Navarro, and Rey-Rocha, 2021).

The financial literature on innovation also proposes that financial limitations constrain firms' participation in R&D (Himmelberg and Petersen, 1994; Bond *et al.*, 2005; Hall *et al.*, 2016). The availability of financial resources can expand a firm's capacity to support its innovative activities (Lee *et al.*, 2001). In contrast, the lack of financial funds may limit firm-level innovation (Chundakkadan & Sasidharan, 2020). However, research from Bicen and Johnson (2014), Berends *et al.* (2014), and De Massis *et al.* (2018) showed that some organisations, particularly small-sized firms, engage in research and innovation despite having limited financial resources. Gibbert and Scranton (2009) and Keupp and Gassmann (2013) especially propose that poverty in financial resources can stimulate firm-level research and innovation. Thus, despite many scholars addressing this subject, the role of financial resources on a firm's process and product innovation in small high-tech firms in high-tech small firms is still debated (Mulkey *et al.*, 2001; Hoegl and Gibbert, 2017: p.842; Guo *et al.*, 2019). Therefore, further investigation is required (Guo *et al.*, 2019). Keupp and Gassman (2013) also suggested a clearer understanding of innovation with poor financial resources.

Similarly, (Perez-Alaniz *et al.*, 2023) investigated how a firm's internal financial resources affect their engagement in research, development, and innovation activities for different firm sizes. Furthermore, they examined whether finance leads to more research and innovation. The result showed that levels of internal financial resources positively influence larger-sized firms (50+ employees) involvement in research, product, and

process innovation. However, financial resources may limit product and process innovation in small-sized firms of less than 50 employees because small-sized firms may consider research and innovation as mitigation when their performance in the marketplace drops instead of seeing this as a reason to grow. This argument is consistent with debates of (Hoegl *et al.*, 2008 Keupp and Gassmann, 2013; Witell *et al.*, 2017). There is a limitation of the study, as the study did not consider a firm's access and leverage of external financial resources, and more research is needed mainly to examine the extent to which financial resources may impact research and innovation in small firms. Thus, further investigation is required. Resource-based theories of innovation have shown how vital internal financial resources are for research and development in developing innovative products and services (Jissink, Schweitzer, and Rohrbeck, 2019; González-Bravo, López-Navarro, and Rey-Rocha, 2021).

Nevertheless, some studies have shown that some small organisations still conduct research relevant to innovation despite their financial constraints (Bond *et al.*, 2005; Berends *et al.*, 2014; Bicen and Johnson, 2014; Hall *et al.*, 2016; De Massis *et al.*, 2018). Similarly, some scholars, such as Gibbert and Scranton (2009) and Keupp and Gassmann (2013), argued that financial resource limitation can stimulate R&D for innovation. Thus, as Weiss, Hoegl and Gibbert (2017: p.842) noted, with many studies researching this topic, the level to which more financial resources impact R&D for innovation still needs to be determined. Also, the orchestration of financial resources in high-tech SMEs remains unclear. Keupp and Gassmann (2013) and Pellegrino and Savona (2017) have also highlighted the need to understand innovation with limited financial resources better. This study addresses these vital gaps not fully explored in literature by examining the effect of small high-tech firm's available internal financial resources on their engagement in R&D to achieve innovation performance in the UK context and how managers of these high-tech firms orchestrate (through resource orchestration) their financial resources to impact their R&D to achieve innovation performance potentially.

3.5.3 Networking Capability

Networking capability is the firm's ability to build, develop and draw on network relationships to access a pool of resources that would otherwise be difficult to access (Hughes, Ireland and Morgan, 2007). Networking capability is the ability of a firm to build and manage network relationships in product innovation (Rindfleisch and Morman, 2001; Vargo and Lusch, 2004). The perspectives from the resource-based view and literature on product innovation suggest that capability drives product innovation performance (Barney, 1991). In product innovation, network relationship management and marketing, results showed that some organisations have created better capabilities for searching for, managing, and leveraging network relationships. Furthermore, networking and interfirm relationships have been an attractive vehicle through which firms can create value (Dhanaraj and Parkhe, 2006; Stuart and Sorenson, 2007; Mu *et al.*, 2008; Borah *et al.*, 2022).

Innovations depend on firm capabilities, and to develop our arguments, we build on present research on capability development. Whereas the related theories of the resource-based view (Barney, 1991) consider firms in isolation, alternative ideas assume that firms can exploit resources located outside firm boundaries (Dyer, 1996; Gulati, 1999, Zaher and Bell, 2005; Wen, Qualls, and Zeng, 2021). Vital and crucial resources may be found in inter-firm routines and processes of a firm's network (Dyer and Singh, 1998). The external environment of SMEs is becoming increasingly powerful. Promoting the innovative performance of SMEs is of practical significance and theoretical value. SMEs often connect with different external networks to obtain technology, knowledge, information, capital and other resources for innovation activities (Hite, 2005; Rojas, Solis, and Zhu, 2018). Research shows that firms occupying the position advantage of the network structure can obtain more information and resources (Westerlund and Svahn, 2008). For instance, firms can build relationships with competitors, suppliers and customers to obtain complementary resources (Ozer and Zhang, 2015). In addition, high-tech small firms can also establish partnerships with universities, jointly conduct technological and product innovation, and promote the transfer of university innovation resources to firms (Rojas, Solis, and Zhu, 2018; Awasthy

et al., 2020). Therefore, network partnerships have become an important way for high-tech SMEs to solve the problem of lack of internal resources, improve their abilities and promote their growth. Hence the choice of networking capability to advance our knowledge of the innovation processes by integrating theories of resource-based view and resource orchestration theory to understand how firms achieve innovation performance.

Furthermore, Innovation is a process that results from various interactions among different actors (Daugeliene, 2008; Doloreux, 2004; Pucci *et al.*, 2018). Under the conditions of fewer resources and less R&D, networks represent a complementary response to insecurity arising from developing and using new technologies that could reduce uncertainties in innovation for SMEs (Diez, 2000; Trang, 2024). Many studies address the role of external linkages in raising innovation (e.g., Doloreux, 2004; Zeng *et al.*, 2010; Yaqub *et al.*, 2020; Adam and Alarifi, 2021). Hewitt-Dundas (2006) stated that external resources and capabilities might provide small firms with the stimulus and capacity to innovate, while the lack of external innovation partnerships significantly negatively affected the likelihood of their innovation. Audretsch *et al.*, (2023) argued that there were substantial differences in the impact of various types of external networks or partners on the innovation process of firms. The concept of networking capability emerged in social networking research. The capability to manage both inter- and intra-firm network relationships has long been recognised as vehicles through which firms innovate, create value, and build competitive advantages (Mu *et al.*, 2011; Kumar *et al.*, 2011; Mu, 2013, 2014; Mu and Di Benedetto, 2012; Theodosiou *et al.*, 2012; Ramkumar, 2020).

Partanen *et al.*, (2020) showed that networks can become a source of strategic resources for SMEs which could enhance firm performance. Interfirm networks can increase access to competitive resources and capabilities in an innovative ecosystem (Tang, Ma, and Jing, 2024). Previous studies suggest that developing and leveraging a unique set of relational capabilities is crucial for the firm to tap into the strategic potential of its network web (Partanen *et al.*, 2020). It is quite known that network structural relationships (Stuart and Sorenson, 2007; Mu *et al.*, 2008; Kiran and Bose, 2020) and relational capacity are

meaningful (Dyer and Singh, 1998; Singh et al., 2022), and few studies are showing how managers of small high-tech firms create value regarding their networking capability (Mu *et al.*, 2017). For example, interfirm relationships research has highlighted the relevance of a firm's networking capability (Capaldo, 2007; Mu *et al.*, 2013, 2017), but the attempt to link this capability to the achievement of an innovative performance and sustainable competitive position in high-tech small firms has often led to results of limited value for researchers and practitioners (Lorenzoni and Lipparini, 1999; Mu *et al.*, 2017; Wang et al., 2024). Thus, the debate on networking capability is still ongoing. Hence, there is a need to investigate this research gap.

The application of the resource-based view (Wernerfelt, 1984; Barney, 1991) has evolved to integrate the inter-firm context by identifying valuable resources, assets and capabilities that reside within networks (e.g. Gulati, 1999). Firms can employ external resources to supplement their resources, increasing their innovation performance and, particularly, the achievement of their firm objectives (Varadarajan & Cunningham, 1995). Dyer and Singh (1998) argued that organisations can only enjoy relational rents that combine, exchange and co-develop distinctive resources with their network partners. Networked firms do not merely respond passively to their existing network relationships (Dhanaraj and Parkhe, 2006); instead, they consciously and intentionally manage and design their networks. They do so to pursue specific network structures or form stronger ties with their partners, and they may also pursue both goals in line with their overall organisational strategies by making use of network capabilities, which are vital for examining the creation of value and utilisation of network resources (Gulati, 1998).

Prior research has identified several network capabilities or competencies of firms which relate to the firms' network management, including network competence (Ritter, 1999; Ritter and Gemünden, 2003), network management capability (Möller and Halinen, 1999), strategic network capability (Hagedoorn, Cloudt, and van Kranenburg, 2006; Zacca, Dayan, and Ahrens, 2015), relational capability (Lorenzoni and Lipparini, 1999; Collins and Hitt, 2006) and networking capability (Mitrega *et al.*, 2012). For example, Ritter (1999) suggested that a networked firm requires network competence to manage its network. Hagedoorn, Cloudt, and van Kranenburg (2006) argued that strategic network capability,

which is the intelligence of firms concerning their network settings and their selection of partners, influences firms' engagement in future activities with partners. Previous research suggested that network capability is the organisational capability toward managing external relationships. It would be positively related to knowledge creation (Zacca, Dayan, and Ahrens, 2015) and innovativeness (Parida *et al.*, 2017) and would finally influence organisational performance significantly (Walter *et al.*, 2006; Mitrega *et al.*, 2012). These show that the network configurations impact a networked firm's performance. Research on strategic management suggested that a networked firm could benefit from its ability to manage itself and all the persons with whom the individual has links, referred to as an ego network.

Furthermore, in product innovation, networking and interfirm relationships have long been recognised as attractive means through which an organisation can create value (Mu *et al.*, 2008; Dhanaraj and Parkhe, 2006; Mu *et al.*, 2013, 2017). However, firms must be able to orchestrate their networks to extract value for firm performance. Also, despite the growing literature on networking capability and innovation performance, we have little knowledge of how managers of small high-tech firms orchestrate their network capability to achieve innovation performance. As a result of this limitation, the framework of resource orchestration theory (structuring, bundling, and leveraging) is adopted to understand how firms operate in dynamic environments to achieve value and innovation performance (Idisondjaja *et al.*, 2023).

3.5.4 Degree of Openness

The concept of SME open innovation is quite well-studied and dominated the attention of many innovation studies scholars (e.g., Brunswicker and Vanhaverbeke, 2015; Jia *et al.*, 2018; Kapetaniou and Lee, 2019; Radziwon and Bogers, 2019; De Marco *et al.*, 2020; Leckel, 2021). Much Research has been carried out to contribute to our understanding of open innovation since its inception by Chesbrough (2003), however, much of its origin is found within big and well-endowed firms, whereby open innovation has been adopted as a strategy. As a result, there is an imbalance in our understanding of openness, within smaller and less-resourced SMEs. Only recently have SMEs garnered some attention

(Greul *et al.*, 2016; Vanhaverbeke *et al.*, 2018; Kraus *et al.*, 2019). Whilst openness provides financial and non-financial benefits (Dahlander and Gann, 2010), despite the organisation size, the challenge of openness can be challenging for SMEs given their scale, resource limitations and managerial objectives (Dooley and O'Sullivan, 2018) and thus may impact how openness manifests itself within such firms. Hence, a need to examine the impact of openness on SMEs.

Much research on open innovation differentiates between two concepts of open innovation: inbound, where new sources of knowledge flow into an organisation and outbound, where internally developed technologies and sources of knowledge or ideas can be acquired by external organisations with business models that are better suited to commercialise a given technology, knowledge, or idea (Chesbrough, 2006d; p. 229). Gassmann and Enkel (2004) mentioned a third type of openness and differentiated between three groups of open innovation processes: Outside-in processes (1), inside-out (2) and coupled processes (3) (Gassmann and Enkel, 2004). Coupled processes are a mixture of outside-in and inside-out processes that leverage well-established strategic alliances with innovation network partners, in which giving and taking are essential for success. From a technology-oriented viewpoint, inbound open innovation – or purposive inflows of knowledge – relates to technology exploration and innovation activities to capture and benefit from external knowledge sources to enhance current technological developments. Past literature mentions external participation, external networking, customer involvement, outsourcing of R&D and licensing of intellectual property (Van de Vrande *et al.*, 2009; Parida, Westerberg, and Frishammar, 2012).

The role of inbound open innovation, more specifically, signifies the most common approach to open innovation among firms (Chesbrough and Crowther, 2006; West *et al.*, 2014) and SMEs particularly (Parida, Westerberg, and Frishammar, 2012; Hervas-Oliver *et al.*, 2021). Inbound open innovation is popular among firms that can acquire technology instead of creating it within the organisation (Bogers *et al.*, 2014; West and Bogers, 2014; Barrett, Dooley, and Bogue, 2021). Consequently, SMEs can leverage inbound open innovation to acquire external resources and enhance their innovative performance (van der Vrande *et al.*, 2009; Bianchi *et al.*, 2010; Hossain and Kauranen, 2016). Past studies

have focused mainly on product innovation and not on process innovation pursued by SMEs (Parida, Westerberg, and Frishammar, 2012; Maes and Sels, 2014; Brunswicker and Vanhaverbeke, 2015; Kapetaniou and Lee, 2019; Marco *et al.*, 2020). In line with this reasoning, further research should investigate the role of inbound open innovation in process innovation to understand SME innovation comprehensively.

The growing literature on open innovation underscores the role of external knowledge for innovation as a critical process of a firm's inbound open innovation activities, where external sources of expertise disseminate into the firm to increase exploration and create commercialisation partnerships (Chesbrough, 2006d; Chesbrough *et al.*, 2006; Harryson, 2008; Dahlander and Gann, 2010; Chesbrough and Bogers, 2014). Empirical research shows that a firm's search strategy influences a firm's capacity to exploit external knowledge for innovation (Laursen and Salter, 2004; Laursen and Salter, 2006). From an open innovation angle, search strategies explain whether firms search beyond their "internal" knowledge base (within the technological and organisational boundaries of the firm) among external sources such as suppliers, universities, customers, consumers, research organisations or universities. Laursen and Salter (2006) explained openness, alluding to the breadth (i.e., number of external sources used) and depth (i.e., how deeply the firm draws on various sources) of external relations. Similarly, Lazzarotti and Manzini (2009) merged two dimensions of openness: the number and type of partners and the number and type of phases of the innovation process opened to external collaborations. This study builds on the definition of Laursen and Salter to investigate the degree of openness effect on technology-oriented SMEs in the UK.

The relationship between a high-tech SME's openness and its innovation performance is a research hotspot in innovation and has achieved many outcomes, but its conclusion is very debatable. For example, Wang *et al.* (2014) found that R&D Openness hurts the firm's innovation output through empirical research on 279 Chinese firms. Knudsen *et al.* (2006) research shows that most of the technology alliances formed by different firms in the innovation process have not undergone rigorous risk assessment, making the firm's original gains and innovation information easy to competitors. Huang and Rice (2009) also believe that firms that value independent technology adoption and development will

have better innovation performance and sustainable development capabilities than those that rely on foreign technology for a long time. Other vital studies show no simple linear relationship between firm openness and innovative performance. Laursen and Salter's (2006) research determined an “inverted U-shaped” relationship between the breadth and depth of open innovation and its innovative performance, while some research shows that the breadth and depth of open innovation of firms have complementary effects on their innovation performance (Sisodiya *et al.*, 2013; Cheng and Huizingh, 2014; Wang *et al.*, 2015; Teplov, Albats and Podmetina, 2019; Pilav-Velic and Jahic, 2022; and Li, Li, and Wu, 2022). These inconsistent conclusions not only lay a foundation for our research but also provide a valuable reference to show that studying the complex relationship between a technology-oriented firm’s openness and innovation performance is necessary from a new perspective.

3.5.5 Conclusion

This chapter provided an extensive review of the relevant academic literature surrounding the research aims of this study. Firstly, this chapter provided an overview of the literature surrounding technology orientation. This chapter has discussed one of the salient concepts within technology literature, i.e., technology orientation. It presented recent developments in the technological orientation concept. Secondly, there was an examination of what constitutes innovation performance and the factors that drive innovation performance. This concept was introduced and defined in relevance to this thesis. This section discusses various strategic firm resources, namely technological resources, financial resources, networking capability and degree of openness. The next chapter proposes a conceptual model and develops hypotheses for examining if named strategic firm resources have a role in the influence of technological orientation on innovation performance and further the role of structuring, bundling, and leveraging of these firm resources on the relationship between availability of named strategic firm resources and innovation performance.

CHAPTER 4: DEVELOPING THE CONCEPTUAL FRAMEWORK

4.1. Introduction

The research background and the gaps in the literature were covered in the previous chapter. Considering that the underlying process and the impact of technology orientation on innovation performance in UK high-tech small enterprises are not well understood. Based on the chosen theoretical framework, this chapter attempts to develop the hypothesis on the influence of technological orientation, strategic firm resources, and resource orchestration on innovation performance in high-tech small firms. As previously said, this study's main goal is to advance our knowledge of how high-tech small firms deploy strategic firm resources to achieve innovation performance, particularly the transformation of technology orientation into innovation performance. This study adopts the Resource-Based View and Resource Orchestration Theory (ROT) to understand the decisions made by the organization. These two theories serve as the theoretical framework for the conceptual model that this doctorate study is based on. It develops seventeen hypotheses, describing how technology orientation influences innovation performance, The roles of availability of technological and financial resources, network capability, degree of openness in the relationship between technology orientation and innovation performance, and the role of structuring, bundling and leveraging between strategic firm resources and innovation performance.

4.2. The Resource-based view and Resource orchestration theory

4.2.1 Resource-Based View (RBV)

People can misunderstand resource-based theory because everyday language understands the term resources differently. It is crucial to distinguish strategic firm resources from other resources. To most people, money is an essential resource. Tangible products such as cars and homes are also necessary resources. Nevertheless,

firms do not consider common resources such as homes and vehicles as strategic resources. Resources such as homes and cars are valuable, but an organisation's competitors can willingly acquire them. Therefore, a firm cannot hope to create a sustainable competitive advantage around common resources (Barney, 1991).

A strategic resource is an asset that is valuable, rare, inimitable, and non-substitutable. For example, Apple has many strategic resources, including their proprietary software and hardware platforms, which have emerged from numerous innovations and improvements over literally decades, the Apple store, and many aspects of the overall buying experience, including a culture of innovation and price. It did not hurt to have Steve Jobs, a charismatic, innovative thinker, as their CEO for many years. Many computer companies have struggled to make money with razor-thin profit margins. Using a different business model focused on its strategic resources, Apple has succeeded with years of record profits (Edwards, 2014). At one time, Apple was the most valuable company in the world based on stocks. Strategic firm resources that are valuable or rare are valuable simply due to the relatively high cost of acquiring them (Edwards, 2018).

One of the first scholars to put forward the significance of resources to an organisation's competitive advantage is Penrose (1959), and she highlighted that an 'organisation comprises a collection of resources' (Penrose, 1959; p.24). She further argued that these resources can only profit the organisation if the organisation exploits them to achieve valuable performance (Penrose, 1959). This view was further supported by Rubin (1973), who said that resources are only beneficial if exploited. He further argued that the firm must process these "raw resources for it to be valuable". (Rubin, 1973, p.937). Wernerfelt (1984) took this further by postulating that if a firm can acquire valuable resources to implement its chosen market strategies, it can achieve above-normal outcomes. The RBV has become immensely popular and relevant in strategic management because researchers in the field have built on Penrose's bits of knowledge to explain how firms can use their resources to differentiate themselves, create advantages over competitors and achieve competitive advantages.

Barney (1991) developed one of the seminal works on business management in history concerning the RBV that formalised the theory into a broad and empirically testable theoretical framework. Barney (1991) furthermore assumed that resources and capabilities are distributed among organisations and are subject to changes. An organisation that possesses valuable, rare, inimitable, and non-substitutable resources is said to outperform rivals when organisations deploy and exploit their resources. Additionally, an organisation that possesses unique resources and can use its capabilities to exploit them optimally will achieve a competitive advantage and enhance innovative performance (DeSarbo, Di Benedetto and Song, 2007; Song, Song and Di Benedetto, 2011;). Overall, in maintaining the aim of an organisation to achieve firm goals such as innovation performance, Barney (1991) listed four main characteristics that a resource must have: it must be valuable, rare, inimitable, and non-substitutable (VRIN). This description of RBV is the most widely accepted concept used in strategic management research; it is not without criticism and limitations (Priem and Butler, 2001). Table 4.1 presents a historical view of the theory.

Table 4.1. The historical view of the underpinning theory and its contribution to RBV

Authors	Contribution to the resource-based view
Penrose (1959)	The firm is a bundle of resources. Its growth depends on the effective use of resources and is limited by managerial resources. The team's entrepreneurship emphasises alertness and judgment. Services rather than resources are stressed.
Barney (1991), Rumelt (1987), and Wernerfelt (1984)	Suggests that resources must be valuable, rare, inimitable, and non-substitutable to be sources of competitive advantage. As a unit of analysis, individual resources Focus on the state (equilibrium) where firms earn a competitive advantage. A strategic resource to one firm is also a strategic resource to another firm—usually, there is no distinction between resources and their services.

Sources: Foss *et al.*, (2007); Galbreath (2004, 2005)

4.2.2 Criticisms of Resource-Based View

One of the limitations of RBV is that firms pay too much attention to choosing resources rather than stressing what a firm does with its resources (Kraaijenbrink *et al.*, 2010). Resources can only be the source of better organisational performance if firms exploit them through organisational processes. Sirmon *et al.* (2011) discovered that previous research suggests that possessing resources is insufficient to achieve better organisational performance. Instead, firms should exploit resources to attain their total value. In other words, RBV does not demonstrate how managers of firms can use resources to attain sustainable competitive advantage.

Another criticism of RBV, as Foss and Knudsen (2003) pointed out, RBV pays little attention to how competition dynamics among organisations occur. As entry limitations and firm-specific resources are not the only things that determine the performance outcome of organisations within an industry, RBV does not explain the effect of competition (Foss and Knudsen, 2003). Another limitation of RBV, according to some researchers, concerns the issue that RBV's applicability is too limited. For example, Conor (2002) argues that RBV applies only to big organisations with a lot of market power. He further said that small organisations sustained competitive advantage cannot depend on their static resources, which is a limitation of RBV.

Finally, the RBV literature overlooks the relationship between resources and leveraging actions (Ndofor, Sirmon, and He, 2009). RBV critics have pointed out that scholars using RBV must focus their research on how resources can be orchestrated to efficiently generate organisational performance, such as innovation performance, which gives the organisation a competitive advantage. Therefore, because of these criticisms, Scholars have suggested a more dynamic framework, one that postulates that resources can only influence performance through the resource-based actions of managers to enable their firms to compete effectively in rapidly changing environments and achieve firm goals (Hunt and Morgan, 1996; Ndofor, Sirmon, and He, 2011; Sirmon *et al.*, 2007, 2011). This framework is named the resource orchestration theory.

4.2.3 Resource Orchestration Theory

In this study, we aim to examine how resource orchestration (Helfat *et al.*, 2007; Sirmon *et al.*, 2011) influences innovation performance at the firm level in the context of decisions concerning the management of strategic resources. Resource orchestration is a new development in resource-based studies (Barney, 1991; Peteraf, 1993).

The resource orchestration theory starts with the belief that just analysing an organisation's resources does not explain performance results and stresses the need to efficiently and successfully manage or “orchestrate” resources (Sirmon *et al.*, 2011; Wales *et al.*, 2013). Also, the resource orchestration theory (ROT) builds upon the RBV by positing that the “possession of valuable, rare, inimitable, and non-substitutable resources

is a vital but not enough condition for achieving performance results such as innovation performance” (Hitt, 2011; Sirmon *et al.*, 2011, p. 1390).

The resource orchestration theory was first clearly discussed in the literature in 2011 by Sirmon *et al.* (2011). However, Sirmon *et al.* (2007) addressed the limitations of RBV and the manager's role in creating customer value. Moreover, Helfat (2007) developed two frameworks that would later serve as the basics of the ROT: Helfat, in his book written in 2009, outlined the *asset orchestration* framework and the resource management framework. Asset orchestration consists of two processes: search/select; here, managers locate and invest in assets. The second process is deployment/configuration; here, a vision of the assets being coordinated is essential. The resource management framework considers how these processes work together (Helfat *et al.*, 2009, pp. 24-30). In 2007, Sirmon, Hitt, and Ireland contributed to the resource management framework by redefining it into “the comprehensive process of structuring, bundling, and leveraging a firm’s resource portfolio” (Sirmon *et al.*, 2007, p. 273). Furthermore, various scholars explained Resource Orchestration (RO) in different ways. Hitt (2011, p. 9) suggested that “RO was first named resource management; these days, scholars mainly use the two names simultaneously”.

Eventually, Sirmon *et al.* (2011, p. 1394) divided RO by saying that “resource orchestration draws upon both *resource management* and *asset orchestration*”. This view is supported by many scholars (Chirico *et al.*, 2011; Ndofor, Sirmon, and He, 2011; Chadwick *et al.*, 2015; Ndofor *et al.*, 2015; Lanza *et al.*, 2016). The two frameworks combined established the basics of the ROT, aiming to achieve resource-based competitive advantage through manager's activities. The resource orchestration process consists of three sub-processes: structuring, bundling, and leveraging (Sirmon *et al.*, 2007, 2011). Structuring involves the process by which firms obtain the resources to bundle into capabilities that the firm will leverage to create value. The structuring process involves acquiring, accumulating, and divesting resources.

Acquiring refers to the firm’s efforts to obtain resources outside the firm in the strategic factor market. Neoclassical economics thinks that strategic factor markets are efficient,

which makes it hard to get valuable, rare, imitable, and no substitutable resources from external sources (Barney, 1986). However, Denrell, Fang, and Winter (2003) say that strategic factor markets may have incomplete resource information, particularly in highly dynamic markets, creating arbitrage opportunities. Thus, the resultant unpredictability mandates the firm to acquire resources to develop and maintain a competitive advantage.

Accumulating refers to the firm's efforts to develop resources internally and is centrally connected with learning. Further, a firm should develop human resources talent to increase tacit knowledge specific to the firm's needs. Training and experience in firm resources and operations are ways to increase resources within the firm. Nevertheless, the needed resources could still be lacking regardless of the firm's efforts. Under these conditions, strategic partnerships between firms may provide the requisite means to gain a resource advantage over competitors (Ireland *et al.*, 2002). Strategic alliances can benefit learning new knowledge in environments with limited resources. By using partnerships, the firm may have opportunities to develop technical and managerial expertise through transfers from its partners, which emerging firms especially need to operate in markets characterised by limited resources (Ireland *et al.*, 2002).

Divesting refers to the firm's efforts to shed existing resources that have proven not to help create value. Divesting activities consist of selling off specific assets, sacking some people, divesting certain non-important aspects of the business, and outsourcing business activities from the central firm. Because the firm has limited resources, divesting is a necessary option to consider while competing in the marketplace. Doing so shifts resources to more valuable or productive assets. However, the firm should be well informed when making these kinds of decisions because if the conditions of the marketplace are not considered by the firm, divesting without being fully informed may hinder the firm from taking advantage of resources of which the firm is not aware, such as tacit knowledge—and may place the firm at a competitive disadvantage. Structuring the firm's resources is essential but not enough to create value. The establishment of a resource portfolio is the foundation for developing capabilities. A capability is to perform a coordinated set of tasks utilising organisational resources (Helfat and Peteraf, 2003).

Thus, the firm should be able to bundle resources into capabilities and then leverage them to create an appropriate value.

Bundling is how a firm integrates resources within its portfolio to create capabilities. Each capability, thus, is a unique combination of resources that allows the firm to take action to create value for the firm and its stakeholders. The term capability can also be referred to as a “bundle of resources” (Hitt *et al.*, 2001, 2003; Sirmon *et al.*, 2007; Sirmon *et al.*, 2011). The bundling process varies based on an organisation’s needs, and different bundling processes produce different capabilities. The firm may bundle a few resources to create low-order capabilities needed for tasks requiring less complexity within the firm.

Further, the firm may bundle many resources to create high-order capabilities for complex tasks intended to change the organisation. Thus, different bundling processes are essential for incremental and radical organisational change (Hamel and Prahalad, 1994; Sirmon *et al.*, 2007). The three sub-processes of bundling are stabilising, enriching, and pioneering (Sirmon *et al.*, 2007).

Stabilising refers to minor incremental changes to existing capabilities. The efforts for improvement are to stabilise the firm’s position in the competitive marketplace (Smith *et al.*, 1985). This process is based on keeping skills up to date and may comprise annual training and development of current employees and refining directives of peculiar projects. Firms currently performing ahead of competitors sometimes use this approach to bundle resources. Capabilities changed through the stabilising process are also referred to as stabilise capabilities. Nonetheless, firms often operate in dynamic competitive environments, and stabilising is unlikely to sustain a competitive advantage. While it is crucial, stabilising is a less effective way to create value for the firm and its stakeholders (Siggelkow, 2002; Sirmon *et al.*, 2007; Sirmon *et al.*, 2011).

The enriching process refers to extending and enhancing a current capability. Capabilities can be enriched by learning new skills to improve employees' current knowledge (earning degrees) or by adding complementary resources to the existing portfolio. The firm may already possess these resources but has not combined them in peculiar ways, or it may acquire them through strategic partnerships, mergers, or

acquisitions. For instance, a technology firm might partner with or acquire a diagnostic firm to increase its ability to gather and analyse data. In summary, the enriching process creates synergies among complementary resources to enrich capabilities. Capabilities enhanced through the enriching process are also named enriched capabilities. Even so, because enriching extends current capabilities, the likelihood of imitation is higher than if the firm chooses to create new capabilities, which occurs with the pioneering process.

Pioneering is the process of creating new capabilities for the firm. Firms may create these new capabilities from existing resources or require new ones (Ahuja and Lampert, 2001). Either way, to create these new capabilities, the pioneering process requires creativity and exploratory learning, which inspire the creation of novel capabilities (March, 1991). For example, Hitt, Harrison, Ireland, and Best (1998) cited SmithKline's acquisition of Beckman instruments as an example of integrating new resources with existing ones to create new capabilities. Through this acquisition, Beckman combined its existing drug research capabilities with new diagnostic technology capabilities to create a new capability in biomedical research. Thus, while the pioneering bundling process may include recombining existing resources, it often entails the integration of new resources with existing ones to create new capabilities. Additionally, a firm functioning in a dynamic and uncertain competitive environment should adopt pioneering as a bundling process to keep up with competitors. A firm should discover new capabilities quickly to stay ahead of rivals wanting to be the first to exploit opportunities. Capabilities formed through the pioneering process are also referred to as pioneered capabilities.

Leveraging these capabilities using three subprocesses of mobilisation, coordination, and deployment: Leveraging' refers to exploiting a firm's capabilities and taking advantage of specific market opportunities. By 'mobilisation', necessary capabilities are spotted, and by 'coordination', these capabilities are joined into capability configurations; these capabilities, through deployment strategies, are physically deployed in the product market. Sirmon *et al.* (2007) noted that while each process and sub-process are vital, each process and sub-process must be synchronised to improve value creation. RO is selected for this thesis as it describes a comprehensive framework that explains the different activities through which resources are orchestrated and strategically leveraged

to generate innovation performance (Andersén, 2021). Table 4.2 presents a historical view of the theory.

Table 4.2 The historical view of the underpinning theory and its contribution to ROT

Authors	Contribution to ROT
<p>Sirmon (2007)</p> <p>Sirmon, Hitt, and Ireland, 2007</p> <p>Helfat <i>et al.</i>, (2009),</p>	<p>The manager's role is to create value for customers and wealth for owners.</p> <p>The comprehensive process of structuring, bundling, and leveraging a firm's resource portfolio.</p> <p>ROT consists of two frameworks. Asset orchestration consists of two processes: search/select, where managers locate and invest in assets. The second process is deployment/configuration, where a vision and coordinated assets are essential.</p> <p>The resource management framework pays attention to how these processes work together (Helfat <i>et al.</i>, 2009)</p>
<p>Sirmon, Hitt, and Ireland, (2011). Sirmon (2011)</p>	<p>"Resource orchestration draws upon both resource management and asset orchestration."</p>

Sources: Sirmon, Hitt, and Ireland, (2011) Hitt, (2009)

4.2.4 Theoretical Background to the Conceptual Model

The technology orientation of the high-technology industry has gained close attention from innovation researchers in recent years (De Luca, Verona, and Vicari, 2010; Urban and Barrera, 2010; Batra *et al.*, 2015; Rezazadeh, Karami, and Karami, 2016). Despite different outcomes among scholars on the direct effect of technology orientation on an organisation's innovation activities to achieve higher innovation performance, the main idea is that organisations that are engaged in research and development and the deployment of the latest technology are more likely to be technology oriented (Damanpour, 2018; Adams, Freitas, and Fontana, 2019). A technology-oriented firm has “the ability and the will to acquire a substantial technological background and to use it in the development of new products” (Gatignon and Xuereb, 1997, p.5). A technology-oriented firm is firmly committed to R&D activities. It acquires and accumulates rare, valuable, inimitable, and non-substitutable resources critical to creating new technologies that could give it an advantage over competitors.

Furthermore, technology-oriented firms strive to acquire the requisite novel technologies and technical knowledge to create new products and services (Zhou *et al.*, 2005; Renko *et al.*, 2009; Adams, Freitas, and Fontana, 2019). These novel technologies are a significant driver in the competitiveness of technology-based SMEs (Zahra and Bogner, 2000). There has been a growing interest in examining the paradox of high-tech SME innovation. For example, Saqib, Zarine, and Udin (2018) proposed a model to investigate the innovation process and the mediating role of technology in the relationship between technology orientation and innovation performance of the organisation. They found that more technological capability could increase the firm's innovation performance. Likewise, Adams, Freitas, and Fontana, (2019) model examined the influence of marketing management on the relationship between technology orientation and innovation performance. The results show that marketing management positively mediates the relationship between technology orientation and innovation performance.

Kedzior *et al.* (2020) conducted research in 31 Polish Technology-Based Firms, and they showed that engagement in resource-intensive activities such as R&D activities and hiring highly skilled people has enabled small high-tech firms to develop innovative products.

Accordingly, technology orientation is essential for fostering innovation and giving organisations the chance to improve their performance in this area, particularly in high-tech organisations where technical improvements happen quickly (Kim *et al.*, 2009). With quick technology advances, businesses can use new information, tools, and resources to enhance their operations, outputs, and services. The direct correlation between technology orientation and innovation performance has been the subject of numerous research and models (Chen *et al.*, 2014; Lee *et al.*, 2015; Saqib, Zarine, and Udin, 2018; Adams, Freitas, and Fontana, 2019). However, few studies have explored the role of strategic firm resources in tech-oriented firms to achieve innovation performance from a resource-based view. Also, no model exists for high-tech small firms in the UK. Furthermore, the direct effect of technology orientation on innovation performance may be present. However, efficient orchestration of strategic firm resources could play a role in achieving sustained innovation performance. To respond to the challenges of fast-growing technologies, organisations need different strategic resources to aid them in their efforts to stay ahead of competitors. Therefore, further empirical research and a model to understand better from a resource orchestration perspective the use of resources (structuring, bundling, and leveraging of resources) in the relationship between technology orientation and innovation performance and the factors that influence this relationship is needed. This conceptual model attempts to present the process of converting technological orientation into innovation performance, investigating factors affecting the process. This conceptual model explores the role of strategic firm resources in small high-tech firms' innovation, including technological resources, financial resources, networking capability and degree of openness. The various hypotheses are discussed and presented below based on the above justification.

4.3 The relationship between technology orientation and innovation performance

Organisations can compete in dynamic business environments through heterogeneous tangible and intangible resources likely to be rare, valuable, and imperfectly imitable (Barney, 1991). According to RBV, a firm's resources and capabilities, including technology, are essential drivers of its performance and competitive advantage (Barney, 1991). Therefore, this study aims to explore technology orientation as the critical driver of innovation that leads to improved innovation performance. An organisation's technology orientation refers to deploying advanced technologies in new product development and fast integration of new technologies that competitors cannot easily copy. As a result, an organisation can achieve innovative performance from its new products (Jeong *et al.*, 2006).

Similarly, Zahra and Bogner (2000) indicated that a TO towards product upgrades plays a significant role in innovation performance. Technology orientation usually involves a strong commitment to R&D activities targeting acquiring and accumulating knowledge of novel technologies. Firms that are technology-oriented strive to gain technical knowledge that rivals cannot easily copy and use in the creation of new processes or products to achieve an advantage over competitors (Zhou *et al.*, 2005; Gao *et al.*, 2007; Renko *et al.*, 2009; Adams, Freitas, and Fontana, 2019). Towards the end of the 1990s, empirical research on technology-based SME firms became popular, especially on how innovative technology drives technologically oriented SMEs (Zahra & Bogner, 2000). Technologically oriented organisations can create technological products and services that can survive in a rapidly changing environment, particularly high-tech firms that are sensitive to technological evolution (Cooper, 2000).

In an ever-evolving technological environment that enables firms to quickly adapt, technology orientation is regarded as one of the most important types of strategic orientation that may quickly establish capabilities (Jiang and Li, 2009). These company competencies can measure how well they innovate to get a competitive edge (Meuter *et al.*, 2000; Calantone, Cavusgil, and Zhao, 2002). According to Rajogo and Ahmed (2006) and Helmers and Rogers (2010), innovation performance (IP) is the result of a company's

knowledge base or synthesis of knowledge, which is the recombination of new and existing information. According to Prajogo and Sohal (2003), to achieve innovation performance, innovative organizations invest in and use the newest technologies with the assistance of the technology orientation strategy in both radical and incremental innovation. Technology orientation encourages firms to achieve Innovation performance by acquiring the latest technology and services (Zeng, Xie, and Tam, 2010). Technology orientation follows the technological-push way to cope with the newest technology and the firm's preferences for high-tech products and services (Ahuja and Katila, 2001). By following the technology orientation strategy, firms maintain relations with reputed vendors who support them in innovation performance and achieving long-term goals (Laursen and Foss, 2003).

Additionally, firms need a broad range of capabilities to underline the role of technology orientation on innovation performance (Kafouros *et al.*, 2008). Innovation performance utilises an idea to increase the product/process, resulting in more usefulness and better performance for a firm (Hu *et al.*, 2009). Literature shows that technology orientation affects new product creativity and export performance (Henfridsson, Mathiassen, and Svahn, 2014). Sales performance and customer orientation (Adams, Freitas, and Fontana, 2019). These results set the foundations for innovation performance (D'Angelo and Presutti, 2019). Technology orientation increases the scope of intelligence and mutual knowledge, which ensures that firms can utilise such information for effective innovation performance (Derwik and Hellström, 2017; Fudickar and Hottenrott, 2019).

Furthermore, Hamel and Prahalad (1994) and Gatignon and Xuereb (1997) showed that TO allows an organisation to achieve the position of technology leadership, resulting in better innovation performance. In a study by (Hamalumba and Kesamang, 2019) on the impact of TO on SMEs' innovation performance in Botswana manufacturing firms, the study adopted a quantitative approach. Findings showed that technological orientation has a significant influence on innovation practices, and this innovation practice results in innovation performance. Al-Ansari, Altalib, and Sardoh (2013) researched the relationship between technology orientation and innovation performance. The study uses survey data from 200 SMEs in Dubai in the United Arab Emirates. The results showed that SMEs in

Dubai are most likely to use technology to facilitate their innovative activities. They showed that the deployment of new technology plays a significant role in enhancing their internal methods and processes. Thus, the firm is encouraged to allot more resources to activities strengthening innovation performance (Gao *et al.*, 2007).

Other studies carried out showed a relationship between technology orientation and innovation performance. According to studies by Peneder (2003, 2010), technologically proficient firms enjoy the commercial success of new products. Furthermore, when technologically oriented firms acquire technological knowledge as a resource, they will contribute to their innovation performance (Bierly and Chakrabarti, 1996; Kocak *et al.*, 2017). In summary, Innovation performance can result from a firm's Technology orientation. The following hypothesis is suggested based on the above discussion.

H1: Technology orientation has a significant and positive impact on innovation performance.

4.3.1 The role of strategic firm resources between technology orientation and innovation performance

To achieve better performance, a firm must analyse its competitive strategies and integrate innovation at the firm level and in its activities (Vossen, 1999). A firm can use different technologies to internally create a new and better product, service, or market process centred on the innovation results (Usai *et al.*, 2021). Examining the role of internal firm resources and capabilities can better understand the innovative potential and constant innovative activities within a firm. This understanding can help a firm achieve better innovation performance (Martínez-Román, Gamero, & Tamayo, 2011). From a resource-based view, it is crucial to analyse the role of firm resources on the relationship between the technology orientation of SMEs and their innovation performance. RBV was first introduced by Wernerfelt (1984) and became a significant part of literature in no time. According to Altaf *et al.* (2019), RBV argues that firm success depends on internal resources, which are classified as the assets or capabilities of a firm. These assets could be tangible and intangible and divided into assets or capabilities. The business's assets could be tangible and intangible (Collis, 1994); however, the firm's capabilities are

intangible, such as networking capability (Teece *et al.* 1997). According to RBV, this study uses intangible and tangible technological and financial resources to achieve innovation performance. Further, internal strategic resources such as a firm's degree of openness are essential to achieve innovation outcomes (Barney, 1991).

Within the resource-based view, resources include such assets as organisational processes, information, knowledge, capabilities, and firm attributes controlled by a firm on a semi-permanent basis, enabling the firm to define and execute successful strategies to achieve firm performance, including innovation performance (Barney, 1991). Although technology orientation could play a role in determining the innovation performance of a firm, the influence of technology orientation on innovation performance is not immediately effective (Al-Ansari *et al.*, 2013). Specifically, there are also some indirect effects between technology orientation and innovation performance. Because innovation is associated with the availability of resources and technology (Chen *et al.*, 2013), The resources must be valuable, rare, inimitable, and non-substitutable and must be effectively managed to produce innovative outcomes (Barney, 1991; Sirmon *et al.*, 2011; Diéguez-Soto, Garrido-Moreno and Manzaneque, 2018).

According to the resource-based view, RBV explores the origins of competitive advantage and performance (Amit and Schoemaker, 1993; Michalisin *et al.*, 1997; Barney *et al.*, 2011); RBV explains the performance differences among firms concerning internal or firm-level factors (Wernerfelt, 1984). Given the leading role of firm resources in high-tech small firms (Gu, Jiang, and Wang, 2016), it is essential to understand how strategic firm resources play a role in the innovation performance of tech-oriented SMEs. Therefore, the following section explores the role of specific strategic firm resources in converting technology orientation to innovation performance. Based on this understanding, this study focuses on four strategic firm resources: availability of technology, financial resources, networking capability and degree of openness.

4.3.2 The mediating role of the availability of technological resources between technology orientation and Innovation performance

Availability of technological resources refers to the internal technological resources present within an organisation that are crucial to a firm's R&D activities for innovation (Bharadwaj, 2000; Grover, 2003). According to Damanpour (2018), firms that engage in research and development and implement the latest technology are more likely to be technology-oriented. Technology orientation is the firm's openness and willingness to adopt new technologies (Jaworski and Kohli, 1993). According to RBV, a firm's resources and capabilities, including technology, are critical drivers of its performance and competitive advantage (Barney, 1991). In this context, technology orientation can be considered a firm's resource, which can be leveraged through business strategy and processes to enhance innovation performance (Nassani *et al.*, 2023). Technology-oriented firms are committed to R&D and developing innovative products that are competitive in the marketplace. Technological resources are required to achieve this competitive advantage in high-tech firms. So, a firm's commitment to R&D propels it to develop and acquire technological resources that primarily use technology to help businesses run smoothly, make jobs easier and keep a firm's record in a secure database. Technological resources can be tangible or intangible. Examples include software (specialists), production systems, finance systems, the Internet, telecommunications, robotics, and automation (to speed up production time). When possessed by tech-oriented SMEs, these resources influence innovation through enhancements in communication, information and knowledge sharing, inter-organizational exchange, and organisational learning processes (Kmieciak *et al.*, 2012). Through these valuable technological resources, customer data can be gathered, which could be used to develop improved products or services (Kmieciak, Michna, and Meczynska, 2012). Consequently, technology orientation influences the availability of technological resources in an organisation.

In strategic management literature, particularly from an RBV perspective, a firm with unique resources and capabilities can compete in a turbulent market and outdo its closed

rivals and industry competitors (Barney, 1991; Anwar, 2018). Through the availability and allocation of technological resources, superior products and services can be created which are more technologically superior and innovative to stay ahead of competitors (Cooper, 1984; Masa'deh *et al.*, 2018; Chen *et al.*, 2014), and these are shown in successful commercialisation (Zahra and Nielsen, 2002; Leng *et al.*, 2015) which eventually enhances the organisation's innovation performance (Leng *et al.*, 2015; Naala and Omar, 2017).

Research shows that technological resources are vital in determining a tech-oriented firm's capacity to engage in innovative activities and enhance performance (Shefer and Frenkel, 2005; Van Beers and Zand, 2014). For example, the study by Du, Peng, and Peng (2020) on high-tech organisations in the growth enterprise market and SME Boards in China showed that in high-tech-oriented organisations, technological resources play a role in helping these organisations conduct R&D to create products that would give the firm a competitive advantage in the marketplace (Du, Peng, and Peng, 2020). Similarly, a study by Rodriguez (2005) found that technological resources for innovation activities could achieve a competitive advantage through new products and process innovation for a technology-oriented organisation. In summary, Success in today's competitive environment requires a technology-oriented company to pursue a coherent technology strategy to articulate its plans to develop, acquire, and deploy technological resources to achieve innovation performance. Based on these arguments, we formulate the following hypotheses.

H2: Availability of technological resources positively mediates the relationship between technology orientation and innovation performance.

4.3.3 The mediating role of availability of financial resources between technology orientation and Innovation performance

Organisational researchers have long studied the question of what the drivers of innovation are. Scholars have identified many factors, such as firm-level and intra-organizational characteristics, industry characteristics, and managerial incentives, as innovation antecedents (Ahuja *et al.*, 2008). Some scholars have also argued that

different internal organisational resources, such as financial resources (Penrose, 1959; Hubbard, 1998), could positively impact the innovation process. Availability of financial resources refers to the internal financial resources present within an organisation. High-technology firms usually suffer from a lack of resources, especially financial resources for technological innovations (Arzubiaga *et al.*, 2018)

Technology-oriented SMEs require a coherent technology strategy to articulate their plans to develop, acquire, and deploy financial resources to achieve superior firm performance (Zahra, 1996). If the firm wants to be a technological pioneer, the firm must invest in internal R&D and acquire relevant technology. Therefore, the availability of financial resources could help tech-oriented SMEs enhance their innovation performance. Being tech-oriented implies that the company is committed to research and development to develop innovative products that will give it an advantage over competitors. Moreover, determining a significant relationship between small firms' technological orientation and innovation performance is essential. A firm's financial capital is a common and comparatively easy resource to convert into other resources, i.e. technology, which is an indispensable resource for tech-oriented firms.

From the theoretical lens of RBV, financial resources can give an advantage over competitors if rivals do not have the same access to financial resources. Financial resources can enable firms to engage in research and innovation (R&I) (Jissink, Schweitzer, and Rohrbeck, 2019; González-Bravo, López-Navarro, and Rey-Rocha, 2021). Past literature on innovation also highlights that limited financial resources hinder firms' engagement in Research and Innovation (R&I) (Himmelberg and Petersen, 1994; Bond *et al.*, 2005; Hall *et al.*, 2016). High-technology firms can use their available financial resources to acquire missing competencies externally (George, 2005). Internal financial resources can make a firm depend less on external markets and allow investments geared towards innovation even during falling financial cycles (Audretsch, Lehmann and Warning, 2004). A firm's technology orientation can help a high-technology firm to acquire technological capability and skilled workers to contribute to creating innovative solutions and developing products and services, and this can result in financial performance for the firm as this generates more financial resources in terms of profit and bank loans (Yang *et*

et al., 2017). So, technology orientation influences the availability of financial resources in the firm (Yang *et al.*, 2017).

Financial slack resources in tech-oriented firms can support innovation performance, allowing high-tech firms to start incremental innovation processes in addition to existing R&D projects (Rothaermel and Deeds, 2004). Extant research also shows that the availability of internal financial resources in tech-oriented firms is vital for developing new products (Mishina *et al.*, 2004). Under these conditions, resource constraints can affect the ability of a firm to engage in innovation and R&D (Zhang *et al.*, 2018). Many scholars debate that financial resources endowment does influence a firm's perception toward innovation by increasing managerial discretion and opportunities for developing nonfinancial capabilities (George, 2005; Patzelt *et al.*, 2008; Pérez-Luño *et al.*, 2011). Wiklund and Shepherd (2005) also reported that small businesses need access to financial resources to achieve and sustain competitive advantage. With access to financial resources, tech-oriented firms can invest in R&D and acquire state-of-the-art technology to develop superior products, introduce new technologies and innovations to the market and achieve innovation performance (Grinstein, 2008; Gu *et al.*, 2016). Therefore, technology orientation can aid in creating new products and innovation performance through strategic financial resources. Based on these arguments, we formulate the following hypotheses.

H3: The availability of financial resources mediates the relationship between technology orientation and innovation performance.

4.3.4 The mediating role of networking capability between technology orientation and innovation performance

Network capability refers to the ability to build and draw on relationships with networks to gain access to resources that are not internally available but are necessary for a firm to implement innovative activities and achieve innovative performance (Hughes, Ireland and Morgan, 2007). Innovation performance has been argued and discussed as an essential factor for firm competitiveness (Powell *et al.*, 1996; Pittaway *et al.*, 2004; Gronum *et al.*,

2012). Researchers and practitioners have suggested that innovation performance is a crucial way to cope with a rapidly changing environment (Gronum *et al.*, 2012). It helps firms manifest creativity and experiment by introducing business models, new products, processes, and services that lead to market success (Gassmann, 2006). Technology orientation can be a crucial element of firm performance, including innovation performance (e.g. Hughes and Morgan, 2007; Kumar *et al.*, 2011; Akgün *et al.*, 2014). A firm's technology orientation can allow high-technology firms to use their networking capability to access network resources to support them in their innovative activities. Technology orientation is an essential technology-based asset that can generate high performance because it allows firms to understand better technological developments, marketing environment, and competitors (Gatignon and Xuereb, 1997).

Therefore, the expectation of positive results linked with technology orientation may encourage firms to actively generate and respond to external technological development to increase the chance of new product performance. In developing and accessing external information, the ability to build networks and deploy network resources plays a crucial role. From the lens of RBV, the networking capability can create significant value through firm collaboration to gain valuable experience and knowledge that rivals cannot easily copy (Kale, Dyer, and Singh, 2002). Network capability can help small firms attract external resources from markets that offer access to their resources due to their limited resources (Galkina and Chetty, 2015; Yenyurt and Carnovale, 2017). Many studies emphasised the role of networked collaborations in enhancing innovation performance (Faems *et al.*, 2005; Gulati, Lavie & Madhavan, 2011; Singh *et al.*, 2016). Networked relationships provide the skills, finance, knowledge, and equipment required for innovation. Collaborative networks culminate in improving existing products and processes and developing new ones (Rothaermel, 2001; Rothaermel and Deeds, 2004).

Network collaborations give rise to a firm's broader knowledge base, resulting in better performance. Networking reduces the risk of intra-network competition, provides a specific system for protecting intellectual property and avoids opportunistic behaviours by building a standard knowledge of the benefits among network members (Pittaway *et al.*, 2004; Mokhtarzadeh *et al.*, 2018). Empirical evidence shows that more networking

experiences will lead to higher performance levels in future collaborations (Gulati, Lavie & Madhavan, 2011). Multilateral interactions between network members discover new opportunities, create new ideas and increase newness. SMEs gain complementary resources and thus implement their technological activities more rapidly (Rothaermel, 2001; Taylor and Helfat, 2009). Rothaermel's (2001) study showed that established pharmaceutical companies with the resources needed to commercialise new technology can better adapt to new technological changes through an alliance with newcomers. Taylor and Helfat (2009) also reported that established companies transitioning to new technology must be in touch with technology developer firms and those with the resources required for commercialising innovation. Therefore, networking can lead to resource synergy and promote innovation by enhancing complimentary resource sharing. Based on the above, this study argues that a firm that brings together a variety of partners through networking can better meet innovation challenges and perform better.

We have argued that technology orientation and networking capability enhance SME innovation performance. We further propose that technology orientation enhances SME innovation performance through its effect on networking capability. SMEs with a high technology orientation are more proactive in the search for technological opportunities and resources (Jantunen *et al.*, 2005; Mu & Di Benedetto, 2012). They are more alert and respond to market intelligence (Johanson and Vahlne, 2009). As technology orientation prompts firms to take risks by investing in R&D, high technology orientation SMEs are eager to join related networks to gain better access to complementary resources and knowledge, build mutual trust and develop commitment between partners, which in turn will help them pursue opportunities (Reagans and McEvily, 2003; Rese and Baier, 2011). All in all, SMEs with higher technology orientation will be better able to overcome their limitations and compete in dynamic markets successfully by developing related networks and strengthening their position in networks (Dyer and Nobeoka, 2000; Uzzi and Lancaster, 2003; Gilsing and Nooteboom, 2005; Vesalainen & Hakala, 2014). Based on the reasoning above, we propose that technology orientation increases the innovation performance of SMEs through the mechanism of networking:

H4: Networking capability positively mediates the relationship between technology orientation and innovation performance.

4.3.5 The mediating role of degree of openness between Technology Orientation and Innovation performance

A firm's openness refers to the number of external sources used and how deeply the firm draws on various sources of external relations. For high-tech SMEs to be successful in innovation, they must somehow be open as they must depend on external sources to access new knowledge and to take advantage of supporting resources such as venture capital, marketing channels, knowledge, financial and technological resources (Stephan *et al.*, 2019; Teplov, Albats and Podmetina, 2019). RBV argues that resources are accessible beyond the boundaries of firms; that is, firms may acquire these resources from external sources to increase their performance (Park *et al.*, 2017). A high-tech firm's technological orientation to overcome its limited resources is to use external technology to support its innovation activities (Chesbrough and Euchner, 2011).

Technological orientation is a foremost firm-level paradigm that shows the firm's ability regarding the technological knowledge, adoption, and implementation of innovative technologies for the firm's success (Chen *et al.*, 2014). High-tech SMEs suffer from resource poverty. Firms can continuously update their knowledge about new technologies to ensure a competitive advantage through openness with external sources. Managers of firms can leverage this knowledge to sustain their competitive advantage (Lavie, 2006). Technological learning is significantly associated with knowledge assimilation, exploration, and exploitation (Bierly III, Damanpour, and Santoro, 2009). Technological learning for new technologies mainly occurs when a firm engages in some openness (Chesbrough, 2003). Openness is essential for successful tech-oriented firms as they learn about the latest technological developments, and this knowledge is integrated into firm innovation activities. Research on information technology systems has shown the vital role played by technology in firm innovation, showing that the desire for the innovative success of a firm leads the firm to engage in openness by accessing and integrating knowledge from competitors, research centres, universities and customers (Bigliardi *et*

al., 2020). Along with this reasoning, the technology orientation of a firm has some influence on how it decides to open its firm boundaries.

Small high-tech firms must engage in some degree of openness as strategic decision-making to try and acquire and allocate resources for R&D activities and apply the latest technology and capabilities to develop more innovative products to satisfy customers. However, there is a problem as SMEs must lose control of valuable, rare, inimitable, and non-substitutable resources to achieve profit and competitive advantage, which seems to be at variance with the principle of RBV. Further, the problem exists that once the organisation has opened to partners, the resources become less inimitable and thus less rare. Against this position, Alexy *et al.* (2018) argue that through strategic openness, the organisation can make the resource more VRIN and not less while maximising profit depending on competitive dynamics, resource maintenance costs and preferences of customers. Openness as a strategic decision ensures access to resources, and thus, organisations are better positioned to exploit these resources and capabilities to create innovations.

Some literature has shown some effect of a small firm's engagement in some degree of openness with different external partners for its innovation performance (Becker and Dietz, 2004; Nieto and Santamaria, 2007; Medeiros *et al.*). Also, Faems *et al.* (2005) proved that as a firm engages in different degrees of openness with diverse partners, the development of new products increases with the variety of partners. The openness toward customers, suppliers, and universities in R&D management is crucial for improving the percentage share of product sales (Lichtenthaler, 2009). Through a firm's degree of openness (Chesbrough, 2003; Chesbrough and Vanhaverbeke, 2006), organisations can enhance their innovation potential by stepping outside their boundaries to share innovation risks with partners, acquire external sources of knowledge to use in their innovation processes (i.e., inbound Open Innovation) and through this, have a better understanding of customer needs and enhance technology development such as better products (Laursen and Salter, 2006; Salge *et al.*, 2013; Cammarano *et al.*, 2017).

A study of Swedish high-tech SMEs has shown that adopting OI practices affects radical and incremental innovation (Parida, Westerberg, and Frishammar, 2012). Thus, a

technology-oriented organisation's openness allows it to access external resources, propelling firms to innovate and continually compete. As a result, an organisation's openness is a critical strategic resource for technology-oriented firms to help achieve their innovation goals. In short, technological orientation influences a firm's innovation performance through openness, which provides an opportunity to develop innovative products and services. Based on these arguments, we formulate the following hypotheses.

H5: The degree of openness positively mediates the relationship between technology orientation and innovation performance.

4.4 The role of resource orchestration between strategic firm resources and Innovation performance

Although strategic firm resources are a crucial determinant of innovation performance and competitive advantage, how the firm resources are orchestrated to achieve innovation and sustainable competitive advantage is not immediately effective (Deligianni *et al.*, 2019). Precisely, how firm resources are orchestrated influences the relationship between the availability of firm resources and innovation performance. Because merely possessing firm resources alone does not guarantee the corresponding innovation results and advantage (Ndofor, Sirmon, and He, 2011; Sirmon *et al.*, 2011). Managers of firms must effectively manage resources attributed to innovation to produce innovative outcomes (Diéguez-Soto, Garrido-Moreno and Manzaneque, 2018). According to the resource orchestration theory, resource management is essential for a firm to achieve value and competitive advantage resulting from innovative outcomes (Sirmon *et al.*, 2011). Given the leading role of resource orchestration in high-tech SMEs (Deligianni *et al.*, 2019). Understanding how resource orchestration influences the innovation performance of technology-oriented high-tech SMEs is vital. Thus, the following section examines the role of resource orchestration in the conversion of the availability of strategic firm resources to innovation performance. This study focuses on three resource orchestration dimensions: structuring, bundling, and leveraging.

4.4.1 The mediating role of structuring, bundling, and leveraging between the availability of technological resources and innovation performance.

Resource structuring is critical to innovation creation because a technological resource portfolio establishes the foundation of a firm's potential innovation creation (Wang *et al.*, 2012). Structuring refers to the process by which firms acquire, accumulate, and divest technological resources. Heterogeneity in technological resources results from choices made in acquiring, accumulating, and divesting technological resources. The structure of a firm's technological resources is the outcome of the firm's earlier resource structuring activities. The resource structuring process can aid organisations in achieving competitive advantage when aligned with the organisation's strategic goals. Organisations have diverse effectiveness in structuring technological resources that align with their competitive strategies and core competencies. For example, Srivardhana and Pawlowski (2007) argued that the ERP system can enable business process innovation as a technological resource.

Past studies have shown that technological resources help a firm understand technological advancements and the corresponding opportunities and risks, thereby increasing performance (Mishra and Agarwal, 2010). Nevertheless, a firm's view of technological progress is intangible, but the growth in firm performance, such as market share, revenue and profit, is tangible (Sarkees, 2011). Thus, if a firm wants to transform intangible perceptions into tangible income, it must pass through some processes. Given that a firm is a collection of heterogeneous resources (Wernerfelt, 1984), we analyse these processes from the lens of resource orchestration.

Firstly, studies have shown that firms with technological resources continually search for technology-related information (Srinivasan *et al.*, 2002), which helps them monitor the most recent technological developments and learn where new technologies can be acquired and accumulated (structuring). Second, firms high in technological resources are more likely to recognise incremental opportunities to enhance their performance (Srinivasan *et al.*, 2002), primarily motivating them to carry out resource bundling to reduce cost.

Resource structuring can provide the necessary resources that firms may not be able to develop internally due to a lack of time or a lack of absorptive capability (Brush *et al.*, 2001; Shane, 2003). Resource structuring represents a favourable channel for transferring needed intangible assets and resources to add to already available resources for innovation (Denrell *et al.*, 2003; Prabhu, Chandy, and Ellis, 2005; Yang, Lin, and Peng, 2011). The infusion of new information from external sources tends to generate the benefits of recombining existing ideas and getting access to new ideas, both necessary for creating innovations that can change the market dynamics (Laursen and Salter, 2006). Firms can effectively extend the scope of available internal resources by broadening the boundaries of their core competencies, which provides a sufficient foundation for solving complex problems (Katz and Preez, 2008).

An example is the case of Sony Corporation of Japan and Samsung Electronics of South Korea. Sony was a leading electronics and consumer goods giant until the mid-1990s. Around the same time, Samsung Electronics was a small but growing rival, especially in the personal electronics industry. Sony possessed a global distribution network, a significant R&D division, and access to high-quality technological resources in Japan (Xu and Muneyoshi, 2016). On the other hand, Samsung was a smaller organisation with no access to resources of similar quality or quantity. However, by strategically structuring its resources, Samsung quickly surpassed Sony as the global leader in consumer electronics with more innovative products. To achieve its goal, Samsung reconfigured and restructured its resources to be efficient, innovative, and agile. This strategy enabled adaptation to rapidly changing consumer preferences worldwide, focusing mainly on growth-oriented emerging markets (Kim, 1997).

As resource acquisition and accumulation is necessary, Managers of firms must bundle different sets of resources to create capabilities to perform the required tasks necessary to achieve their strategic goals (Rothaermel and Hess, 2007). The availability of technological resources can help a firm's overall capability to utilise existing resources, widen existing resources, and integrate new resources into current resource portfolios. Regardless of their stage of development, firms need to continuously make minor incremental improvements, extend current capabilities and, sometimes, build entirely new

capabilities to grow organically through innovation (Sirmon *et al.*, 2007). Resource bundling means two resources interacting with each other and working together to improve performance. Strategic literature highlights the importance of bundling resources to generate superior firm performance (Penrose, 1959). The availability of technological resources can enhance tech-oriented firms' bundling process by erecting a technological edge to maintain their competitive advantage through internal mechanisms, such as causal ambiguity, secrecy over resource attributes, and so on (Li and Atuahene-Gima, 2001).

Internal technological resources can allow firms to enhance their knowledge of resource attributes, integrate newly acquired resources with existing resources, and bundle them into their capabilities to create innovations (Hoang and Antoncic, 2003). According to ROT, bundling a firm resource portfolio into capabilities, with each capability being a unique combination of resources, allows the firm to take specific actions (e.g., marketing and R&D) to create customer value (Sirmon *et al.*, 2007). In the IT context, firms bundle systems deeply embedded within IT processes and possess unique functionality, thereby creating IT capabilities (Pavlou and El Sawy, 2006). This bundling action may benefit innovation outcomes; the specific action's effect likely changes depending on the firm's life-cycle stage. For example (e.g., SmithKline acquired Beckman instruments to combine its drug research with Beckman's capabilities in diagnostic technology to create new capabilities in biomedical research (Hitt *et al.*, 1998). Another example is the case of Barclays Bank, where it bundled its technology resources simultaneously by restructuring its backend and front-end IT infrastructure and providing training to its staff; it was able to support many IT initiatives requested by customer service and executives. By doing this, it was able to use this new resource more efficiently along with the recent tech-savvy employees it had trained, and through this, it could deliver more innovative products and services.

Similarly, Srivardhana and Pawlowski (2007) contend that the ERP system, a technological resource in a tech-oriented organisation, can enable business process innovation if strategically bundled into a technological capability essential to realise their strategic goals. Under this condition, technological capabilities, rather than the resources

themselves, are the main reason that organisations gain superior performance (Saraf, Langdon and Gosain, 2007) and sustain competitive advantage (Mata, Fuerst and Barney, 1995; Saraf *et al.*, 2007).

To realise value in the marketplace, Leveraging emphasises mobilising, coordinating, and deploying these capabilities in the market to capture value (Nevo and Wade, 2010; Sirmon *et al.*, 2011). A firm's technological resources can enhance a high-tech firm's resource-leveraging process through mobilising, coordinating and deployment mechanisms. Regarding resource mobilising, technology resources can help the firm understand engineering and R&D (Sirmon *et al.*, 2007). Concerning resource coordination and deployment, technological resources can increase demand from customers and the market (Dong *et al.*, 2013). Therefore, a high-tech firm's internal cross-functional partnership will become more efficient and effective, vital for resource coordination and deployment (Sirmon *et al.*, 2007). Furthermore, technological resources can also enhance a leader's management knowledge and other essential skills crucial in resource-leveraging.

A firm's internal and technological capabilities reflect its strong and diverse technology resources, enriched through continuous bundling processes. These capabilities play a critical role when deployed strategically by managers and are vital in generating innovations (Ahuja and Katila, 2004; Ahuja and Lampert, 2001). For example, Samsung began with few resources to develop semiconductor products. However, through the license of a 64K DRAM design from Micron and the purchase of a design from Zytrex, Samsung assimilated, imitated, extended, and enhanced the technology and ultimately leveraged the technological capability to develop more innovative products (Lee and Slater, 2007). By contrast, Sony, a former technology giant, lost its leading position because of its choice of BETA rather than VHS technology. To summarise the reflections mentioned above, we formulate the following hypotheses.

H6a: The structuring of resources positively mediates the relationship between the availability of technological resources and innovation performance.

H6b: The bundling of resources positively mediates the relationship between the availability of technological resources and innovation performance.

H6c: The leveraging of resources positively mediates the relationship between the availability of technological resources and innovation performance.

4.4.2 The mediating role of structuring, bundling, and leveraging between the availability of financial resources and innovation performance.

Financial resources in high-technology environments are significant resources in executing resource-intensive activities such as R&D and innovation (Kellogg and Charles, 2000; Singh *et al.*, 2019). Thus, firms' action plans and strategies are either implemented or limited by financial resources (Story *et al.*, 2015; Zhang *et al.*, 2018). Therefore, under the condition that with some available internal financial resources, more financial assets and non-financial assets could be acquired and accumulated from strategic factor markets and combined, and the firm could channel these resources into their R&D activities to develop innovative products and services potentially. Firms with financial resources can exploit new opportunities by investing in potentially innovative projects and divesting from non-viable ones. They can also respond to threats from their environments. Managers of tech-oriented SMEs must spend money on innovative activities. These expenditures typically focus on what can be seen (Arundel, Bordoy and Kanerva, 2008), consisting of the purchase of computer hardware, software and advanced machinery, training about deploying new products or processes and buying of licenses, for example (Lopez-Rodriguez and Martinez-Lopez, 2017). Thus, the availability of financial resources influences the firm's acquisition of tangible and intangible assets, which is vital to achieving innovation.

Furthermore, through structuring, other non-financial resources acquired and accumulated, such as technological capabilities, can be strategically used in the innovation process to achieve innovation performance (Deeds, Decarolis, and Coombs, 2000). Studies have shown the importance of acquiring and accumulating financial resources for innovation. For example, according to Khan *et al.* (2020), financing access is critical for SMEs to achieve long-term performance goals. Access to finance improves

an organisation's long-term viability by facilitating market entry, increasing innovation and entrepreneurial activities, and improving risk management skills. Similarly, Burchi *et al.* (2021) argued that providing small businesses with low-interest loans increased their access to finance and thus enhanced their performance.

Similarly, Halilovic *et al.* (2019) discovered that increasing the availability and quality of finance sources encouraged businesses to implement circular economy initiatives. In addition, at the firm level, recent studies have concluded that firm-level resources, defined as resources 'available to the firm that can be easily deployed to various uses (Chen *et al.*, 2012; Mishina *et al.*, 2004; Nohria and Gulati, 1996), are essential to innovation in the form of research and development strategies of firms' (Mousa and Chowdhury, 2014). At the inter-firm-level scholars have shown the role of financial resources that a firm access and accumulates through its network relationships, such as local R&D collaborations (Wang and Li-Ying, 2015), managerial ties (Shu *et al.*, 2012), are drivers of innovation. Peteraf (1993) asserts that financial resources can be a source of competitive advantage even though they are not themselves unique or difficult to imitate.

Financial resources play a pivotal role in resource orchestration. As a critical type of financial slack resource, cash flow enables firms to introduce flexibility, build a buffer against an economic shock and restructure new resource portfolios to build resilience (Lee, 2011; Azadegan, Patel, and Parida, 2013; Tognazzo *et al.*, 2016). Financial resources can stimulate innovation because more financial resources mean more flexibility to experiment with new ideas, bringing in more and better-qualified people to generate ideas and more prototype testing, potentially draining financial resources (Hoegl, Gibbert, and Mazursky, 2008). High levels of available financial resources enable firms to bundle their resources into capabilities by building and upgrading infrastructure, skills, and knowledge assets appropriate for supporting innovation activities (Zhang *et al.*, 2018).

According to ROT, firms must bundle or enrich relevant strategic resources to restructure a new resource portfolio to fit the external environment, improving existing capabilities and further deploying those capabilities to create innovations (Sirmon *et al.*, 2011). Thus,

financial resource availability increases a firm's willingness to convert its resource portfolio into different capabilities and use it for technological innovation. Also, firms with financial capability can use their knowledge to secure more financial capital for innovative activities, which allows them to create products and services that would meet the challenges of a changing business environment (Ye and Kulathunga, 2019; Areo, Gershon, and Osabuohien, 2020; Babajide *et al.*, 2021).

Financial resources can act as leverage that enables organisations to adapt successfully to external pressures, initiate strategic changes to adjust to the external environment (Bourgeois, 1981; Makkonen *et al.*, 2014), and help protect firms against environmental changes (Cyert and March, 1963; Lin, Cheng, and Liu, 2009). Specifically, available cash can quickly be mobilised and re-deployed to purchase new types of machinery, hire talented people, or invest in R&D, marketing, build new capabilities and facilitating the transfer to a more profitable business model and achieve firm innovation goals (Mishina *et al.*, 2004; Mousa and Reed, 2013). Extant research suggests that increasing financial investment in R&D positively affects firm performance (Artz *et al.*, 2010). Thus, leveraging the firm's technological capability brings competitive advantages through current product cost reductions, improvements in product quality and new product innovations (Henderson and Cockburn, 1994; Hall and Lerner, 2010; Berchicci, 2013).

More importantly, leveraging investment in R&D can be seen as an option to expand the creation of new products (Ferreras-Méndez *et al.*). Given that R&D investment provides firms with a variety of opportunities in the future to orchestrate their resource portfolio and business model flexibly and rapidly (McGrath and Nerker, 2004; Lee *et al.*, 2008). By recombining, bundling and deploying these resources, SMEs can accumulate more innovation competencies (Caloghirou, Kastelli and Tsakanikas, 2004). In summary, firms with financial resources can stimulate innovation through the proper orchestration process. Hence, we present our hypothesis as follows.

H7a: The bundling of resources positively mediates the relationship between the availability of financial resources and innovation performance.

H7b: The structuring of resources positively mediates the relationship between the availability of financial resources and innovation performance.

H7c: The leveraging of resources positively mediates the relationship between the availability of financial resources and innovation performance.

4.4.3 The mediating role of structuring, bundling, and leveraging between Networking capability and innovation performance.

A firm's networking capability is an asset for managers. Vital resources are embedded in a well-established portfolio of partnerships and can offer an advantage over competitors in SMEs' network relationships (Barney *et al.*, 2001; Grant, 1996; Wiklund *et al.*, 2009). Innovation is generally a network-based or collaborative phenomenon (Edquist, 1997). A firm, through its network capability, could use inter-organizational relationships to access various resources held by networks of actors (Kale, Dyer, and Singh, 2002). Indeed, innovation happens in networks of actors across multiple contacts (Burt, 1992; Shane and Venkataraman, 2000; Giardino *et al.*, 2022). Scholars such as Sullivan and Marvel (2011), Thorgren, Wincent, and Örtqvist (2009), Schilling and Phelps (2007), as well as Safardoust *et al.*, 2023, all agree that a broader range and network of actors support innovation. The establishment of networks of actors has many essential benefits for SMEs (Robinson, 1982).

SMEs typically lack economies of scale in research and have limited access to knowledge and other critical innovation resources (Mohannak, 2007; Galetti and Tregenna, 2022). They also have limited capacity to manage the whole innovation process individually. Hence, they are advised to cooperate with other organisations, which will probably result in acquiring knowledge and resources (OECD, 2010b). Through a firm's networking capability, a firm can engage deeply with external partners to acquire knowledge, assets and resources (Bullinger, Auerhammer and Gomeringer, 2004; Dittrich and Duysters, 2007; Harryson, 2008). Networking capability can allow firms to benefit from co-development relationships either in the early or later stages of the innovation value chain or in both (Vanhaverbeke and Cloudt, 2006; Dittrich and Duysters, 2007; Harryson, 2008). For example, studies show that network relationships are vital at various stages of the innovation value chain (Christensen *et al.*, 2005; Van de Meer, 2007; Wu *et al.*, 2022).

Therefore, a broad scope and depth of co-development partnerships might positively influence innovation outcomes. These partnerships may grant access to complementary operational assets already in the development phase of innovation (Teece, 1986; Vanhaverbeke and Cloudt, 2006). For instance, Christensen *et al.* (2005) showed that even in an early phase of the switch amplifier technology, successful innovations required the alignment of three complementary assets (science-based assets, high-tech product design assets, and lead-user assets) and operational assets (Manufacturing, distribution, and marketing). To succeed in innovation and create value, small firms must establish relationships to access complementary innovation assets and other vital resources that usually take several years of experience to acquire (Christensen *et al.*, 2005).

Furthermore, indirect and direct cooperation increases a firm's access to required inputs in the process of innovation, including accumulating vital skills through the combination of complementary skills and collective learning that occurs within networks of actors (Pittaway *et al.*, 2004; Alinaghian and Razmdoost, 2018; Garousi Mokhtarzadeh *et al.*, 2020). Lavie (2006) further suggests that through external alliances with a network of actors, a firm can modify its business direction to drive innovation through external learning by changing, acquiring, or divesting resources. Mody (1993) further argued that a firm can increase its innovative performance by acquiring new knowledge, concepts, and expertise through an external network of actors. Developing solid exchange cooperation is critical in allowing a small firm to gain valuable external resources (Stam and Elfring, 2008; Ahlin, Drnovšek and Hisrich, 2014). Such cooperation acts as a resource shield against changes in the market. It helps a small firm to take on risky projects and actively develop innovative products that would be much more challenging to achieve without cooperation (Black and Boal, 1994; Alinaghian and Razmdoost, 2018).

Innovation networks need to mobilise and re-configure network resources to survive. Remarkably, the bundle of resources in an innovation network are notably relevant (Lichtenstein and Brush, 2001). A resource bundle consists of a wide variety of resources that work together, not merely at the firm level but also at the network or market levels. For a high-tech firm, such a bundle of resources includes technological resources and financial capital (Lichtenstein and Brush, 2001). Networking capability increases the

effectiveness and efficiency of resource bundling within small firms by facilitating access to a bundle of resources in an innovation network through its network relationship. For instance, by partnering with external networks, it could access bundles of financial resources crucial for experimentation in the research and development process. Consequently, this enhances innovation capability (Land *et al.*, 2012) and positively influences long-term innovation performance (Partanen *et al.*, 2008). Similarly, through a network of relationships, a firm has access to exploratory and exploitative knowledge, which, when bundled, becomes a technical capability that can be used in developing new products and improving and commercialising a product (Land *et al.*, 2012).

Furthermore, by networking with external actors, firms can more effectively enrich their capability by integrating knowledge and technological capabilities and exploiting innovation strategies using increased knowledge concerning customers' needs and suppliers to achieve successful innovation (Verona, 1999). Networking capability can enable the formation of trust in collaborative relationships, which is necessary for encouraging practical innovation (Nielsen and Nielsen, 2009). With higher networking capability, firms operating in a dynamic environment with rapid changes in technology, such as technology-oriented small firms, can leverage their capabilities as they engage in dense networks and not repeated partnerships (Goerzen, 2007) and, through this engagement, can obtain fresh ideas and discover the most likely future technological trends. These ideas are integrated into the firm's R&D activities and develop high-technology products that generate value (Jenkin and Floyd, 2001; Andriani, 2011; Dougherty and Dunne, 2011).

In summary, possessing well-developed relational skills and the ability to coordinate partners into supportive interactions allows small firms to enhance their competitive positions more effectively. The capability to develop relationships and facilitate resource exchange between network partners enables small firms to access additional resources that can be structured, bundled, and leveraged to enhance innovation (Parida, Westerberg, and Frishammar, 2012).

H8a: The structuring of resources significantly and positively mediates the relationship between networking capability and innovation performance.

H8b: The bundling of resources significantly and positively mediates the relationship between networking capability and innovation performance.

H8c: The leveraging of resources significantly and positively mediates the relationship between networking capability and innovation performance.

4.4.4 The mediating role of structuring, bundling, and leveraging between degree of openness and innovation performance

Innovation is a significant factor in many firms' competitiveness (Li and Atuahene-Gima, 2001; Danneels, 2002). The reason is that firms with a high level of innovation can obtain a competitive advantage and gain higher firm performance than rivals (Koufteros *et al.*, 2005; Wadhwa *et al.*, 2016). Innovation often needs significant resources, which is problematic for SMEs, who usually do not have all the resources they need for their innovation activities (Sorescu and Spanjol, 2008; van Burget *et al.*, 2012; Del Giudice *et al.*, 2021). Opening firm boundaries to external partners, competitors, suppliers, and customers, for example, to access scarce resources is very important for creating innovation (Chesbrough *et al.*, 2014) and achieving firm success and growth (Jawahar and McLaughlin, 2001; Sirmon *et al.*, 2011). Bianchi *et al.* (2010) make the case for an increasing role of open innovation in SMEs, as they showed that technology and products are becoming more complex. Therefore, it is becoming challenging for a small firm to participate in product and technology development independently. As the competence and knowledge needed for such development are scattered across firms and institutions (universities), it makes sense to open firm boundaries to collaborate with external partners (Frishammar *et al.*, 2012).

Similarly, high-tech firms seeking to increase innovation performance can, by the degree of openness, facilitate the acquisition and accumulation of external sources for innovations (Munster, 2011; Pustovrh *et al.*, 2017). The sources of innovation, which are then integrated and combined into the R&D activities of the SMEs, could result in the ability to develop and achieve long-term strategic innovation goals (Villena *et al.*, 2011).

A study of Swedish SMEs has shown that adopting open innovation practices has given them access to external resources to integrate into their innovation process and thus continually innovate to be competitive (Parida, Westerberg, and Frishammar, 2012). As a result, an organisation's openness is a crucial innovation strategy for acquiring and accumulating vital resources that are critical for innovation (Cousins and Menguc, 2006; Paladino, 2007, 2008; Sermon *et al.*, 2007; Villanueva *et al.*, 2012; Esper and Crook, 2014). A firm's openness to seek externally unique resources such as finance, materials, knowledge, and critical information about new technologies makes it necessary to integrate individually distinct resources with external resources and bundle them together to create pioneering capabilities (Sirmon *et al.*, 2011). These pioneering capabilities are further integrated and synthesised into firm R&D activities to develop innovative technologies that result in innovative performance (Chen and Paulraj, 2004; West and Bogers, 2014; Torchia and Calabrò, 2019; Barrett, Dooley, and Bogue, 2021).

Openness not only allows firms to leverage their capability to search for technology-related information and monitor the most recent technological developments connected with technology vendors, but it also inspires them to create value. Technology-related information is acquired to complement internal R&D efforts, and the products and innovations developed are mobilised and deployed in the marketplace for value creation. For example, Barrett, Dooley, and Bogue (2021) showed that the CEO/Managers of high-tech SMEs in Ireland enhanced their technological innovation through inbound openness by searching out (identifying and attracting support) to secure resource exchange, assessing (recognising the value of externally controlled resources) and nurturing appropriate value to support innovation activity. This process has not only allowed SMEs to develop technological novelty but also inspired them to create value. By integrating external resources with internally controlled resources within the organisation, there is the sharing of knowledge, and there is co-learning and co-creation to create technological capabilities, which is crucial to the organisation's aspiration to develop innovative products. These innovative products are leveraged in the market to capture value and realise innovative performance.

In summary, firms that engage in open innovation frequently search for technology-related information, which helps them monitor the most recent technological developments and learn where new technologies can be acquired and accumulated (Srinivasan *et al.*, 2002). Thus, technology-sensitive companies with better access to technology vendors should theoretically show a more significant advantage over competitors. Also, companies are more likely to recognise incremental opportunities to improve their business operations (Srinivasan *et al.*, 2002), encouraging them to conduct resource bundling to achieve cost reductions and efficiency improvements. These capabilities allow them to allocate diverse resources for innovation activities and develop products and services by mobilising and deploying them in the marketplace, enhancing innovation performance. Based on these arguments, the following hypothesis has emerged:

H9a: The structuring of resources positively mediates the relationship between openness and innovation performance.

H9b: The bundling of resources positively mediates the relationship between openness and innovation performance.

H9c: The leveraging of resources positively mediates the relationship between openness and innovation performance.

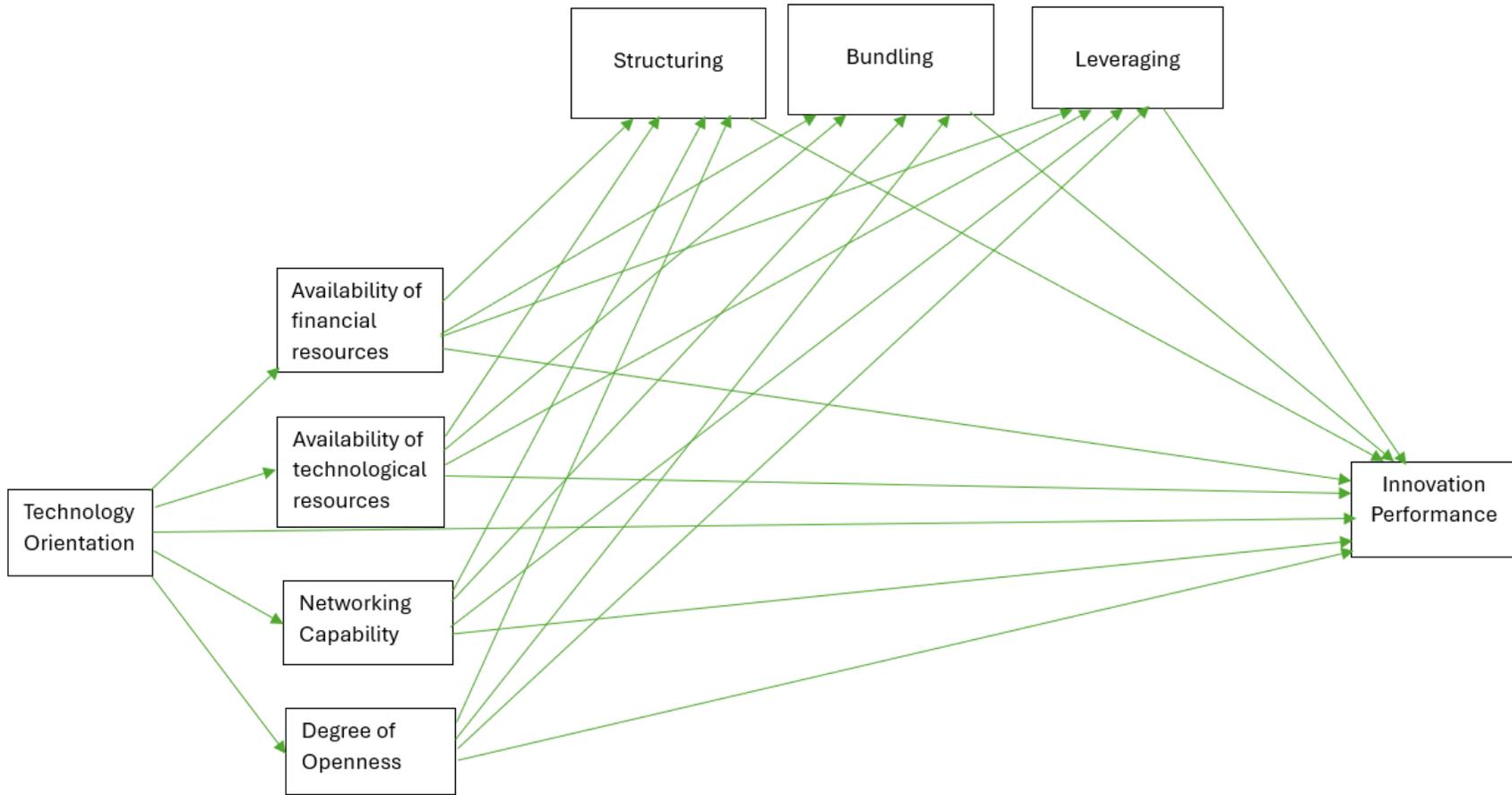


Figure 4.1 The Conceptual Model of this research

4.4.5 Summary

This research draws on the perspective of the resource-based view and resource orchestration theory to investigate the impact of technology orientation on innovation performance, the impact of technology orientation on strategic firm resources, namely (technological resources, financial resources, networking capability and degree of openness) and how the resource orchestration through structuring, bundling, and leveraging of these strategic firm resources can achieve innovation performance. The resource-based view states that the strategic and heterogeneous resources available to a firm can enable a firm to gain a competitive advantage over rivals if those strategic resources are valuable, rare, inimitable, and non-substitutable (Barney, 1991; Desarbo, Di Benedetto and Song, 2007; Song, Song and Di Benedetto, 2011). The resource orchestration theory suggests that it is not the availability of resources that results in sustainable competitive advantage but instead the orchestration of these strategic firm resources by managers of firms that results in sustainable competitive advantage performance that results from innovation performance (Sirmon *et al.*, 2007; 2011).

By combining these two theoretical perspectives, this doctoral thesis proposes a conceptual model examining how technology orientation influences innovation performance through strategic firm resources, specifically the role of the availability of strategic firm resources on the relationship between technology orientation and innovation performance. Additionally, the role of resource orchestration is between the availability of strategic firm resources and innovation performance. In the first section, the model draws on a resource-based view to examine the role of the availability of strategic firm resources between technology orientation and innovation performance. Secondly, the model draws on resource orchestration theory to explore how using these resources could result in innovative performance, specifically, the mediating effect of structuring, bundling and leveraging between available strategic firm resources and innovation performance. This research further explains the “black box” of innovation. The next chapter will outline the methodology and methods to test the model and the hypotheses developed in this chapter.

CHAPTER 5: RESEARCH DESIGN AND METHODOLOGY

5.1. Introduction

The previous chapter develops the conceptual model of the study. This chapter is concerned with research methodology. This chapter introduces sections on research philosophies based on their ontology, epistemology, axiology, and methodology. Also, the justification for choosing the research philosophy adopted in this thesis is detailed. There was a definition of different approaches, their strengths and weaknesses, and justification for selecting the adopted research approach. Also, the various research design choices were analysed and outlined. Furthermore, this chapter also examines the population, sampling, and data collection procedures, the validity and reliability analyses of quantitative research measures, and checks for common methods bias and ethical considerations.

5.2 Research Design Choice, Justifications, and Implementation

The research design involves selecting methods, sampling, data collection, and interpretation processes (Blumberg *et al.*, 2014; Bryman and Bell, 2011, 2022). According to Saunders, Lewis, and Thornhill (2019), a research design is a broad strategy for addressing a research question. Furthermore, the relationship between the research question, the literature review, the data analysis, and the findings is what Royer and Zarlowski (2001) characterized as research design. Research design, according to Blumberg, Cooper, and Schindler (2014), is an outline that demonstrates the general direction and organization of a study. As a result, researchers define research design as the strategy for conducting research that combines philosophies, approaches, strategies, and related methods of inquiry (Creswell, 2009; Creswell and Poth, 2016; Creswell and Creswell, 2017). Although definitions vary, it is crucial to know there is a clear view that research design is core to the entire research activity. It provides a framework for producing evidence appropriate for investigating research questions, which is its main feature (Bryman and Bell, 2011, 2022; Bryman and Bell, 2011; 2022; Denzin and Lincoln, 2011; Blumberg, Cooper, & Schindler, 2014). The plan for gathering, measuring, and

analyzing data is the research design (Cooper, 2018). It serves as a framework for comprehending the connections between the variables in the study (Blumberg, Cooper, & Schindler, 2014). It provides logical evidence to support conclusions about causal relationships between the variables being studied, outlining the general framework and focus of the relevant research (Bryman and Bell, 2011; Blumberg, Cooper, and Schindler, 2014). In this sense, choices about research philosophy, which direct the selected research approach, are either overtly or implicitly included into research design. The choice of inquiry strategy, which in turn affects the choice of research methodologies, is influenced by the research methodology. A collection of strategies and procedures for gathering and analyzing data is what is known as research methodologies (Gill, 2014; Cooper, 2018; Saunders, Lewis, and Thornhill, 2019). Figure 5.1 below shows the research onion.

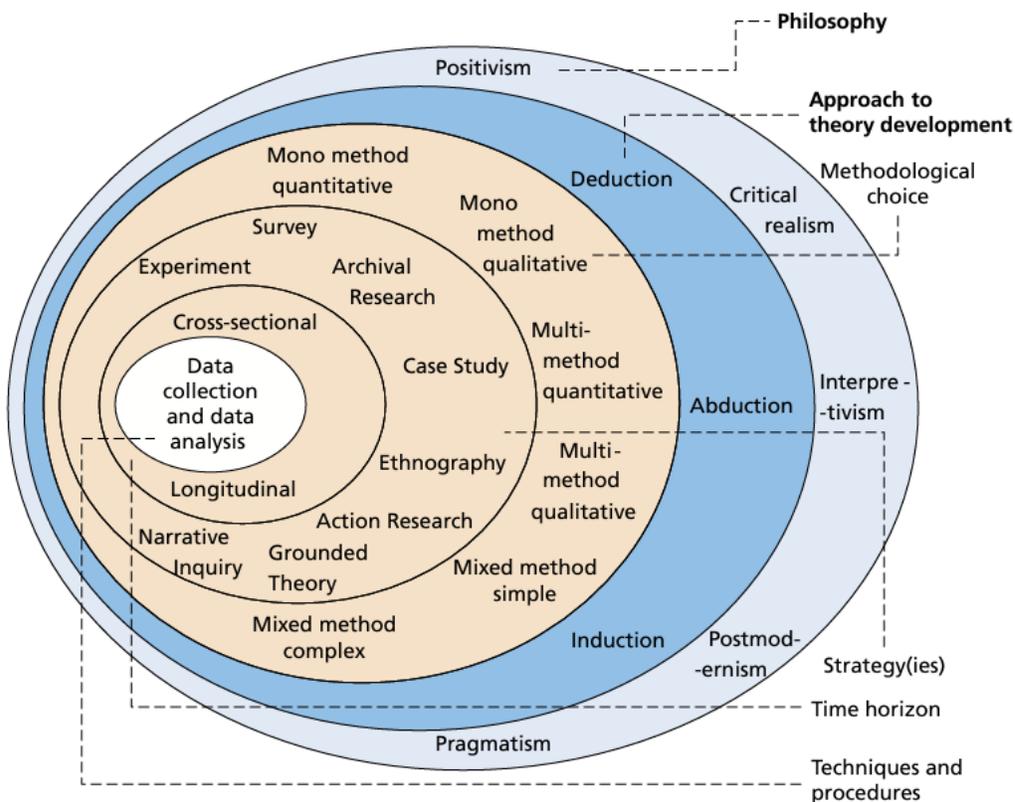


Figure 5.1 The Research Onion Layers

Source: (Saunders, Lewis, and Thornhill, 2019)

5.3 Research Philosophy

Research philosophy comprises a set of assumptions/beliefs about knowledge development (Saunders, Lewis, and Thornhill, 2019). Not only does research philosophy show the association between knowledge and the process of developing it, but at every stage of research, whether the researcher is aware or not, assumptions will be made at every research stage (Saunders, Lewis, and Thornhill, 2019). These include the nature of reality (ontological assumptions), what constitutes acceptable knowledge (epistemological assumptions), and the ways and levels to which your values influence the process of research (axiological assumptions). These assumptions determine how the research questions are understood, the methods used, and how you analyse your results (Crotty, 1998). A credible research philosophy will comprise a consistent and well-thought-out set of assumptions, which will serve as a basis for the choice of methodology, research strategy, and methods of data collection and analysis procedures. This process allows for designing a logical research project in which all research elements align.

When conducting research, human nature and action and how they anchor the ontological difference between social phenomena and objects of investigation in natural sciences should be considered (Bryman and Bell, 2011; McAuley *et al.*, 2007). Any research philosophy adopted shows an interlink of epistemological, ontological, axiological, and nature of human action considerations (Guba and Lincoln, 1994; Crotty, 1998; Denzin, 2008; Mertens and Ginsberg, 2009; Lawrence Neuman, 2009; Creswell, 2014). Despite several differences in terminology, there are generally four research philosophies, i.e., positivism, interpretivism, realism (transformative), and pragmatism (Saunders, Lewis, and Thornhill, 2009; Creswell, 2018). Social science has four significant streams according to classification: positivism, interpretivism, critical realism and pragmatism. Thus, four main traditional contrasting philosophies can be adopted when researchers want to conduct research (Johnson, 2004). The following section discusses the different philosophies.

5.3.1 Positivism

Positivism refers to the philosophical position of the natural scientist and includes working with observable social reality, which is ordered to generate law-like generalisations. Positivism originated in the works of Auguste Comte, Francis Bacon, and the early twentieth-century group of scientists and philosophers known as the Vienna Circle (Compte, 1975). Thus, it is pertinent to examine the positivist assumptions about the nature of reality (ontology), knowledge (epistemology), and values (axiology).

Ontology: The Positivist ontology believes that the world is external (Carson *et al.*, 2001) and that there is a single tangible reality to any research situation or phenomenon, irrespective of the researcher's belief or perspective (Hudson and Ozanne, 1988). Therefore, the approach to conducting research is structured and controlled as it identifies a clear research subject, develops the correct hypotheses, and adopts an appropriate research methodology (Churchill, 1996; Carson *et al.*, 2001). Positivists believe that reality is objective and independent of the researcher's interest in it, and they must use constant logical and rational methods to research (Carson *et al.*, 2001).

Epistemology: For the positivists, the nature of knowledge is inherent in the world of natural science. Positivists view knowledge as observable and measurable facts or statements of belief that can be tested empirically, verified, confirmed, or disconfirmed and are stable and generalised (Eichelberger, 1989; Saunders, Lewis, and Thornhill, 2019). Knowledge comprises complex data, is objective, and, thus, independent of the values and feelings of the researcher. Positivists believe researchers only need the right data-gathering instrument or tools to produce absolute truth for a given inquiry.

Axiology: For the positivist, all inquiries should be value-free. Researchers should use scientific methods of gathering data to achieve objectivity, independence, and neutrality during the inquiry process. Postpositivists, however, modify the assumption that the researcher and the subject of study are independent by recognising that the investigator's theories, hypothesis, and background knowledge can strongly influence what is observed, how it is observed, and the outcome of what is observed.

The main argument against positivism is its lack of recognition that there is an ontological difference between objects of investigation in natural sciences and social phenomena.

Unlike natural sciences, social sciences centre on human behaviour, which has an internal logic of its own. This internal logic should be examined to determine why an individual behaves the way they do (Gill and Johnson, 2010). The following section will discuss this latter perspective.

5.3.2 Interpretivism

Interpretivism, like critical realism, emerged as a criticism of positivism; however, it was from the perspective of a subjectivist. Interpretivism stresses that humans are different from physical occurrences because meanings are generated. Interpretivism examines these meanings. Interpretivism arose in early- and mid-twentieth-century Europe in the work of French, German, and occasionally English thinkers and consists of many components, primarily phenomenology, hermeneutics, and symbolic interactionism (Crotty, 1998). Thus, it is pertinent to examine the interpretivist assumptions about the nature of reality (ontology), knowledge (epistemology), and values (axiology).

Ontology: Regarding what reality is, the interpretivists believe that it is socially constructed (Creswell, 2003; Mertens, 2008; Saunders, Lewis, and Thornhill, 2019) and that there are as many intangible realities as people are developing them. Therefore, reality depends on the mind and a personal or social construct. Do you believe, for example, that Aliens exist? If you do, it is your reality, a way in which you try to make sense of the world around you. In this manner, reality is constricted to space, context, time, and individuals or groups in each situation and cannot be generalised into one shared reality. These assumptions are a direct challenge to the positivist's assumption about the existence of a tangible external reality. The assumptions legitimise conceptions of realities from all cultures. There are individual realities as well as group-shared realities. The question is how these assumptions about the nature of reality are integrated into the research process (Chilisa and Kawulich, 2012).

Epistemology: Interpretivists believe knowledge is subjective because it is socially constructed and mind-dependent. Interpretivists believe that theories and concepts are too simplistic and that there is a focus on narratives, perceptions, and stories (Saunders, Lewis, and Thornhill, 2019). The truth lies within the human experience. Statements on

what is true or false are culture-bound, historical, and context-dependent, although some may be universal. Within this context, communities' stories, belief systems, and claims of spiritual and earth connections find space as legitimate knowledge (Chilisa and Kawulich, 2012).

Axiology: Interpretivists posit that, since reality is mind-dependent and mind-constructed and knowledge subjective, the social inquiry is, in turn, value-bound and value-laden. Your values influence you, which dictates the paradigm you adopt for the research topic you want to study, the methods you choose to collect and analyse data, how you analyse the results, and the way you report the results. As an interpretivist researcher, you admit the value-laden nature of the study and report your values and biases related to the topic under study that may interfere with neutrality (Chilisa and Kawulich, 2012).

5.3.3 Critical Realism

The Realism worldview states that there is a reality whose existence is independent of people's knowledge and explanation. Therefore, social scientists should examine and understand this truth (Bhaskar, 2008; Bryman and Bell, 2011; Johnston and Smith, 2010; Saunders, Lewis, and Thornhill, 2009). Critical realism philosophy focuses on what we see and experience regarding the underlying structure of reality that shapes the observable events. Critical realism originated in the late 20th century in the work of Roy Bhaskar as a response to both positivist direct realism and postmodernist nominalism and occupies a middle ground between two positions (Reed, 2005). Therefore, it is relevant to examine the realist assumptions about the nature of reality (ontology), knowledge (epistemology), and values (axiology).

Ontology: For Critical realists, reality is the most vital philosophical consideration, and a stratified and layered ontology is crucial (Fleetwood, 2005). For Critical realists, the stratified/layered ontology comprises the Empirical (events that are observed or experienced), the Actual (events and non-events generated by the real; may or may not be observed), and the Real (causal structures and mechanisms with enduring properties).

Epistemology: The knowledge acquired in this discipline is socially constructed rather than objectively determined (Carson *et al.*, 2001, p.5) and perceived (Hirschman, 1985; Berger and Luckman, 1967, p.3: in Hudson and Ozanne, 1988). Furthermore, for critical

realism, knowledge is historically situated and transient as facts are social constructions with a historical causal explanation as a contribution (See Table 4.1).

Axiology: Research is value-laden; the researcher is biased by world views, cultural experiences, and upbringings. These affect research findings. Researchers try to minimise errors and bias. Furthermore, researchers acknowledge that what we experience is 'the empirical', in other words, sensations, which are some of the manifestations of the things in the real world instead of the real things. Critical realism claims there are two steps to understanding the world. First, there are the sensations and events we experience. Second, there is the mental processing that goes on sometime after the experience, when we 'reason backwards' from our experiences to the underlying reality that might have caused them.

5.3.4 Pragmatism

Pragmatism is a philosophical belief stating that sometimes selecting one philosophical paradigm (e.g., positivism) rather than another (e.g., interpretivism) may not be practicable. Therefore, pragmatism proposes that the most crucial determinant for selecting a research philosophy is the nature of the research question(s). Another position about worldviews comes from the pragmatists. Pragmatism comes from the work of Peirce, James, Mead, and Dewey (Cherryholmes, 1992). Recent scholars include Murphy and Murphy (1990), Patton (1990), and Rorty (1990); there are many types of this philosophy, but for many, a pragmatic worldview arises out of situations, actions, and consequences rather than antecedent conditions (like postpositivism). Thus, it is pertinent to examine the pragmatist assumptions about the nature of reality (ontology), knowledge (epistemology), and values (axiology).

Ontology: For the pragmatists, reality matters as the practical effects of ideas, and knowledge is valued for enabling successful actions. Furthermore, 'Reality' is the practical consequences of ideas, a flux of processes, experiences, and practices (Saunders, Lewis, and Thornhill, 2019).

Epistemology: A significant underpinning of pragmatist epistemology is that knowledge is always based on experience. Our social experiences influence one's perceptions of the world. Each person's knowledge is unique as she/his unique experiences create it.

Nevertheless, much of this knowledge is socially shared as it is created from shared experiences. Therefore, all knowledge is social knowledge (Morgan, 2014). Epistemology does not view knowledge as reality (Rorty, 1980). It is constructed to manage one's existence better and participate in the world (Goldkuhl, 2012).

Axiology: For a pragmatist, research begins with a problem and aims to contribute practical solutions that inform future practice. Researcher values drive the reflexive inquiry process, which is initiated by doubt and a sense that something is wrong or out of place, and which recreates belief when the problem has been resolved (Elkjaer and Simpson, 2011)

Table 5.1 Philosophical differences between different approaches

Philosophical Assumption	Positivism	Interpretivism	Critical Realism	Pragmatism
Ontology (Researcher's view of the nature of reality)	The reality is external, objective and not dependent on social actions. It is independent of the researcher.	Reality is intrinsic and subjective, dependent on social actions and socially constructed. It is multiple in nature and may change. Researchers may perceive it differently.	Satisfied/layered (the empirical, the actual); External, independent; Objective structures	Reality is the practical consequences of ideas and the flux of processes, experiences, and practices.
Epistemology (Researcher's view on what constitutes valid and acceptable knowledge)	Observable phenomena can provide credible data and facts. The researcher is independent of the phenomena or the participants being researched. The research subject is reduced to causality and law, like phenomena.	Research phenomena can be subjective and socially motivated. The researcher interacts with the phenomena or the participants being researched. The research focuses on the details of the situations, subjective reality, and motives behind the situations and social actions.	Knowledge historically situated and transient; Facts and social constructions; a historical causal explanation as a contribution.	The practical meaning of knowledge in specific contexts; Focus on problems, practices and relevance; Problem-solving and informed future practice as a contribution
Axiology (Researcher's view on the role of value in research)	There is Value-free research, and the Researcher is detached, neutral and independent of what is researched. Researcher maintains. objective stance	Researchers are part of what is researched. The researcher is subjective, and the researcher is an integral part of the research process interpretations. The research is value-bound.	Value-laden research; researcher acknowledges bias by work views; Minimise bias and errors; Objective	Value-driven research: Both objective and subjective view

Methodological Approach (Research process)	Deductive approach. Research is context-free. Generalisation leads to prediction, explanation and understanding.	Inductive approach. Research is context-bound. Patterns and theories are developed for understanding.	Methods chosen must fit the subject matter, quantitative or qualitative	Mixed or multiple method designs, quantitative and qualitative
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Source: (Creswell and Clark, 2011; Saunders, Lewis, and Thornhill, 2019).

5.3.5 Positivism versus Interpretivism

Most social science research is grounded in positivist and interpretivist philosophical perspectives, as previously mentioned. The positivist research paradigm's philosophy is based on objectively studied social reality and ontological questions. Other principles are also part of positivism. According to Bryman (2012), theory seeks to develop testable hypotheses that allow for the evaluation of explained laws and highlight deductivism's tenets. The alternative viewpoint, which demonstrates the inductivism principle, holds that knowledge is created by gathering facts that form the foundation of law. Conversely, the positivists and interpretivists are not the same thing. Institutions are different from subjects in the natural sciences. According to Collis and Hussey (2008) as social scientists have pointed out, the evolution of interpretivism is a means of overcoming the flaws in the positivist philosophical approach. They think that any topic related to people and their organizations is different from those in the natural sciences. The social sciences are distinct from the natural sciences in that they must be approached logically in order to study the social world.

To comprehend the "causal explanation of its course and effects," social scientists must have an interpretive grasp of positive social action (Bryman, 2012, p. 121). Over the years, management research's philosophical framework has changed and become more diverse, which has also given rise to legitimate criticism of positivist ideology. The positivist philosophical commitment, which holds that it is feasible to observe the social world objectively or neutrally and so collect "positively given" facts to test theoretical predictions, has been the primary target of critique (Gill and Johnson, 2010, p. 54). "We inevitably influence what we see when we observe the world," the critics observed. Any researcher using a positivist philosophy should make sure that the outside influences at each step of gathering data is kept to the minimum by creating an effective strategy to address the problem. There is a continuous debate about the validity of using the positivist approach in the study of social science.

Critics point to its objective perspective on reality and its belief that everything observable is real (Sarantakos, 2005; Fraser, 2014). Critics hold that reality is enmeshed in human thought and perception, which are internal, and that not everything can be sensed. Because realism of the positivist presumes that the social world can be precisely and casually explained from outside observation, critics refer to it as naïve realism (Guba and Lincoln, 1994). Nonetheless, positivists argue that it would be incorrect to equate positivism with natural science (Bryman, 2012). The behavior rather than the individual are important in this situation, and they can be summed up into a generalized law. Such a study has a theoretical base and is very structured. Empirical validation and statistical analysis are employed to confirm this theoretical base. Table 5.1.1 shows the similarities and differences between positivism and Interpretivism.

Table 5.1.1 Similarities and differences between the Positivist and Interpretivist paradigms at various levels

Positivist Paradigm	Interpretivist Paradigm
Common Terms	
Mainstream	Alternative
Quantitative	Qualitative
Objectivist	Subjectivist
Scientific	Humanistic
Experimentalist	constructivist
Traditionalist	Nominalist
Main features	
It tends to produce quantitative data.	It tends to produce qualitative data.
Uses large samples	Uses small samples
Concerned with hypothesis testing	Concerned with generating theories
Data is highly specific and precise.	Data is rich and subjective.
The location is artificial.	The location is natural.
Reliability is high	Reliability is low
Validity is low	Validity is high
Generalises from sample to population	Generalises from one setting to another

Methodologies	
Cross-sectional studies	Action research
Longitudinal studies	Ethnography
Surveys	Feminist perspective
Database analysis	Grounded theory
Meta-data analysis	Hermeneutics
	Participative enquiry

Source: Adapted from Fraser (2014)

Table 5.1.2 below shows a set of philosophical approaches and methods used to conduct this research. The reasons for adopting these perspectives or methods are explained.

Table 5.1.2 Research Focus of the study

Ontology	Objective
Epistemology	Positivist
Methodology and Theory Building	Hypothetico-Deductive
Techniques	Statistical Testing
Research design	Empirical-Survey Research
Data Collection Method	Questionnaires
Research Design	Implementation; Analyse Data; Reporting Finding

5.3.6 Justification for adopting the positivist paradigm

This study adopts a positivist paradigm after examining paradigms such as positivism, interpretivism, critical realism, and pragmatism. From an ontological perspective, the researcher can analyze the study objectively and without letting their values, beliefs, or interests get in the way by taking an objectivist stance. There is very little interaction with participants during the research process, and the study is entirely objective. This process is essential to address the study's research questions, which aim to provide an unbiased

assessment of the connection between technology orientation and innovation performance of small, high-technology firms in the UK.

A positivist approach is thought to be the most suitable epistemology from an epistemological standpoint for examining the connection between technology orientation and innovation performance in high-tech SMEs. This study aims to determine how a firm's innovation performance is impacted by its technology orientation. Additionally, it seeks to understand how resource orchestration and various strategic firm resources can improve innovation performance in a high-tech SME. From an epistemological standpoint, genuine knowledge is validated by scientific methods and sciences. The researcher reviewed relevant management theories, including resource-based views and resource orchestration. The theory clearly defines hypotheses and the unit of analysis, and access to data enables the random selection of a suitable data set. The data gathered from the study's unit of analysis is being used to test hypotheses that have been developed based on the body of existing literature. As a result, laws may become more generalised.

Axiologically speaking, research has no value, and the researcher is detached from what is researched. This study aims to comprehend how technological orientation affects the innovation performance of small, high-tech UK firms. Here, the behaviour of the social and institutional actors is being objectively examined to investigate reality. The researcher is impartial, disengaged, and unaffected by institutions and social actors. Plack (2005) asserts that the positivist paradigm is a suitable philosophical approach for this investigation since it favours tried-and-reliable techniques to investigate the phenomenon comparatively objectively. Hence, the positivist paradigm is an appropriate philosophical approach for this study. Table 5.1.3 shows how the positivist philosophical paradigm is used in this study.

Table 5.1.3: The Positivist philosophical paradigm used in this study.

Basic Principles	Positivism	Design of Study
World View	External and Objective	There is intense rivalry among high-technology SMEs. Many factors, both internal and external, can influence the success of their innovation. Resources, capabilities, changes in the market, government competitors, suppliers, customers, etc., can influence the success of a technology orientation in addition to the firm's innovation performance. This phenomenon is external and needs to be studied objectively.
Involvement of the Researcher	Independent	Extant literature is used to develop a conceptual framework and hypothesis. The hypothesis is to be tested to confirm the developed hypothesis.
The researcher's Influence	No interference with the values and beliefs of the researcher	The data is collected from a population of high-technology SMEs in the UK. A stratified random sampling method is used. Statistical methods were used to analyse the collected data to avoid any bias by the researcher.

Observed phenomenon	Facts observed objectively	Technology orientation, Innovation performance, Strategic firm Resources (technological resources, financial resources, networking capability and degree of openness).
Research concepts	Clearly defined and measurable	Technology orientation, Resource-based view, Resource orchestration theory, Innovation performance.
Unit of analysis	It should be the smallest unit and narrowed to the simplest form	Firm-level Study High-technology SME
Results Generalization	Through Statistical Probability	The questionnaire survey method is utilised. The theory and hypothesis were tested, and the results were subjected to validity and reliability tests.

5.3.7 Research Approach

A research approach is compulsory to develop and enhance the validity of a study (Creswell and Clark, 2011). Consequently, it is a general orientation of the relationship between theory and research (Bryman and Bell, 2011, p11). The extent to which there is clarity about the theory before collecting the data determines the approach taken to collect it and its research design. There are three main approaches in research design: The inductive approach, the deductive approach, and the abductive approach (Saunders, Lewis, and Thornhill, 2019). Hence, increasing research efficacy requires a total understanding of these approaches (Boxter and Jack, 2008). A “top-down” research

approach is followed by a deductive approach, whereas “bottom-up” research is followed by an inductive approach (see Figure 5.2).

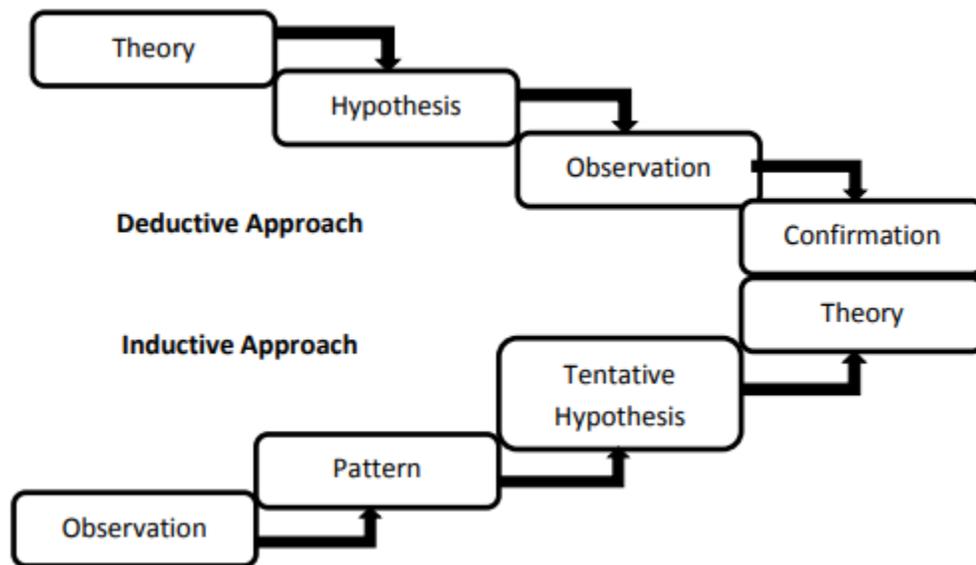


Figure 5.2: Research process in inductive and deductive approaches

Source: Trochim (2006)

5.3.7.1 Deductive Approach

The deductive approach often starts with a theory generated from reading academic literature, and to test the theory, a research strategy is designed (Saunders, Lewis, and Thornhill, 2019). There is no doubt that theories can be helpful. They can support, organise, and synthesise what we know about a phenomenon. In addition, a well-stated theory predicts and controls the future. Furthermore, the deductive approach involves testing a pre-determined theory or hypothesis (Gratton and Jones, 2009). This approach aids researchers in proving a hypothesis by using extant theories. To realise the research goals, present theories are rejected or accepted. (Gill and Johnson, 2010). The advantage of a deductive approach includes allowing a focused method of testing hypotheses. Also, it provides a way to explain causal relationships between the variables and the concepts. However, it has disadvantages, such as not encouraging divergent thinking and may also constrain the range of creativities. Deductive approaches are

primarily associated with positivist philosophy (See Table 4.1). There is also a deductive theory-based hypothesis confirmation because this method is typical in scientific research and involves creating hypotheses and theories (Spector et al., 2014). Therefore, statistical or numerical data are used in the study most of the time, but not always (Wall and Stokes, 2014). But because the deductive method is referred to as the "top-down" approach, it proceeds from theory to confirmation and from the general to the specific (Barratt et al., 2011; Karami, 2011).

5.3.7.2 Inductive Approach

This approach starts by collecting data to examine a phenomenon, and a theory is sometimes built or generated as a conceptual framework; the approach is inductive (Saunders, Lewis, and Thornhill, 2019). This approach emerged because social science researchers are wary of the deductive approach, which allows a reasoning approach that enables a cause-effect relationship between specific variables without knowing how human beings interpret their world (Saunders, Lewis, and Thornhill, 2019). The inductive approach relates to real-life examples that need subjective analysis from the researcher (Priest and Hallebone, 2009). It is called the "bottom-up" approach. It moves from specific observations to theory. Inductive inference refers to drawing general conclusions based on a limited number of observations. The researcher assumes that what is valid for the observed cases may also be valid for the whole population (Bryman and Bell, 2011; Hempel and Oppenheim, 1948). Since inference is not dependent on any premises, discovering new knowledge is unlimited. Research using an inductive approach to reasoning is likely to focus mainly on the context in which such events occur. Hence, a small sample size might be better than a large number, as with the deductive approach (Saunders, Lewis, and Thornhill, 2019). However, the weakness of the inductive approach is that it is limited in sample size and is not specific to the extent to which the researcher can generalise the findings. In the inductive approach, researchers are more likely to use qualitative data and different methods to collect data to establish separate views of circumstances.

5.3.7.3 Abductive Approach

Instead of moving from data to theory (as in the inductive approach) or theory to data (as in the deductive approach), an abductive approach moves back and forth, in effect mixing the inductive approach and deductive approach (Suddaby, 2006). These often agree with what many management researchers do (Saunders, Lewis, and Thornhill, 2019). Abduction starts with observing a surprising fact; the researcher develops a credible theory of how this could have happened. Van Maanen *et al.* (2007) observed that some reasonable theories can account for what is seen better than others, and it is these theories that will assist in uncovering more surprising facts. These surprises, they debated, can happen at any stage in the research process, such as when the researcher writes the project report. Van Maanen *et al.* (2007) also noted that induction and deduction complement abduction to test reasonable theories. Due to the flexibility of the abductive approach, researchers use it from different research philosophies. Some have debated that because pure induction or deduction is hard to achieve, most management researchers use some element of abduction. However, a well-developed abductive approach is most likely underpinned by post-modernism or pragmatism, and critical realism also underpins it.

5.3.8 Justification for Research Approach Chosen

Every approach has its advantages and disadvantages. Given that the researcher has developed hypotheses from the existing literature and a positivistic approach is possible, the researcher will use a deductive approach, i.e., there is a test of theory. The deductive approach is concerned with deducting conclusions from propositions. Based on the resource-based view and resource orchestration theory, the researcher formulates seventeen hypotheses developed from existing literature on the relationship between technology orientation and innovation performance and the role of strategic firm resources in the relationship. The deductive approach allows data through a survey questionnaire to be collected to test the hypothesis developed. Then, the findings are analysed, and the hypothesis is rejected or accepted. Figure (5.3) illustrates the process of the deductive approach.

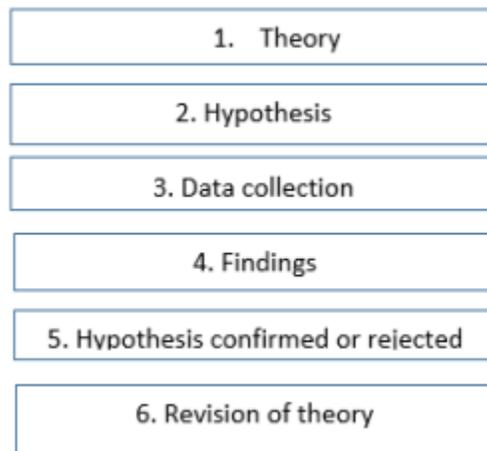


Figure 5.3 Deductive Approach

Source: Bryman and Bell, (2011)

5.4. Research Strategy

Developing a precise plan to gather relevant data that will address the research questions is an essential step in the research process. The research strategy should specify exactly how the researcher intends to gather the data and the techniques, and instruments suggested to gather the data, and this needs to be in line with the researcher's chosen research philosophy, paradigm, and methodology (Saunders, Lewis, and Thornhill, 2019). Grounded theory, action research, surveys, case studies, experiments, and ethnography are some of the methods used in business and management research studies. While grounded theory and ethnography are linked to interpretivism and an inductive approach, other strategies, like the survey and experiment, are associated with positivism and the deductive research approach. Nevertheless, some of these strategies can be related to both philosophical paradigms, such as a case study (Collis and Hussey, 2014). The researcher should develop a research strategy that corresponds to the aim and objectives of the study and choose the most suitable tools and methods.

5.4.1 Research Method

Methodology, according to researchers, describes the steps used while conducting research (Swartz et al., 1998; Saunders, Lewis, and Thornhill, 2009). Researchers can use an approach to address an issue in this way. As stated According to (Sandelowski et al., 2012; Wall and Stokes, 2014), a methodology is a conceptual framework of ideas and concepts linked with a set of general guidelines to do research. As a result, the process involves planning and arranging both theoretical and practical activities. As a result, the methodology links the theory with a strategy that offers a communication rule that focuses on research paths to achieve outcomes. The rules are updated by this system, and the processes are continuously improved. In social science, researchers focus on developing novel methods for observations, analysis, conclusions, and generalizations (Blumberg, Cooper, and Schindler, 2014). There are three research methods: qualitative, quantitative, and mixed methods. Any of these methods chosen provides a specific direction for the techniques used by the researcher in data collection and analyses (Creswell, 2014; Saunders, Lewis, and Thornhill, 2019).

While qualitative research strategies place more focus on words than on quantification in data collecting and analysis, quantitative research strategies place more emphasis on quantification (Bryman and Bell, 2007). Qualitative research sees "social reality as a constantly shifting emergent property of individuals' creation," which is in line with interpretivism and the inductive approach (Bryman and Bell, 2007, p. 78). In contrast, deductive research views social reality as external to objective reality and uses positivism to test the theories. Quantitative data analysis techniques are suitable to accomplish the goals of this study and provide answers to the research questions, in keeping with the positivistic and deductive approach used for this investigation. Similar studies have employed the survey method, one of the popular quantitative techniques in business and management research (Bryman and Bell, 2007). Interviews and questionnaires are commonly used data collection techniques in survey methods. This study adopts a survey questionnaire tool to collect the data from high-tech SMEs in the UK to test the hypothesis developed in this study and to validate the results.

5.4.2 Quantitative and Qualitative Research Method

One way of differentiating quantitative research from qualitative research is to distinguish between numeric data (numbers) and non-numeric data (images, video clips, words, audio recordings, and other similar material). In this way, 'quantitative' is often used as a synonym for any data collection technique (such as a questionnaire) or data analysis procedure (such as statistics or graphs) that generates or uses numerical data (Saunders, Lewis, and Thornhill, 2019). This design may require a deductive approach focusing on testing a theory (Saunders, Lewis, and Thornhill, 2009). Positivism is generally associated with quantitative research designs, mainly when used with predetermined and highly structured data collection methods. Nevertheless, researchers consider it a philosophical exaggeration to suggest an exclusive relationship between quantitative research design, positivism, and deductive approach (Bryman, 2011; Walsh *et al.*, 2015a). Instead, a difference needs to be made between data about the characteristics of firms and people and data based on opinions. Also, researchers may conduct quantitative research designs within pragmatist and realist philosophies.

In contrast, 'qualitative' is often used as a synonym for any data collection technique (such as an interview) or data analysis procedure (such as categorising data) that generates or uses non-numerical data. This process mainly depends on the inductive approach, which emphasises theory building/generation (Bryman and Bell, 2011). Researchers frequently link qualitative research to interpretive philosophy (Denzin and Lincoln, 2011). It is interpretive because researchers must understand the subjective and socially constructed meanings indicated by the researched situation. Such research is sometimes naturalistic since researchers must work within a research context or natural setting to establish trust, access to meanings, participation, and in-depth understanding. Researchers may conduct qualitative research within pragmatist and realist philosophies like quantitative research. In practice, much qualitative research design also uses an abductive approach to theory development where researchers develop inductive inferences and deductive ones are tested iteratively throughout the research.

This process is a crucial way to differentiate this methodological choice; however, this distinction is problematic and narrow. It is not easy because, in practice, many management and business research designs are likely to mix quantitative and qualitative elements. There are several reasons for this. For example, a research design may use a questionnaire. Still, it may be essential to ask respondents to answer some 'open' questions in their own words rather than ticking the appropriate box, or it may be necessary to conduct follow-up interviews to seek to explain the results from the questionnaire. Equally, researchers may analyse qualitative research data quantitatively or use it to inform a subsequent questionnaire design. In this way, quantitative and qualitative research may be two ends of a continuum, which in practice are often mixed. A research design may, therefore, mix methods in a few ways. Table (5.1.4) illustrates the differences between qualitative and quantitative methods in five major points.

Table 5.1.4 Differences between qualitative and quantitative methods

	Qualitative	Quantitative
Objective	<ul style="list-style-type: none"> - Provides insight for setting research problems and generalising ideas 	<ul style="list-style-type: none"> - Generalizing results from a sample to a population - Measuring different views in a selected sample
Sample	<ul style="list-style-type: none"> - Small samples 	<ul style="list-style-type: none"> - Large samples represent the population.
Data collection	<ul style="list-style-type: none"> - Interview/discussion! - Focus groups! - Cases - Observation 	<ul style="list-style-type: none"> - Questionnaire - Online questionnaire - Structured interviews
Data analysis	<ul style="list-style-type: none"> - Mostly non-statistical 	<ul style="list-style-type: none"> - Statistical

Outcome	<ul style="list-style-type: none"> - Exploratory. - Findings cannot be generalised 	<ul style="list-style-type: none"> - Generalized result. - Conclusive
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Source: adapted from Blumberg, Cooper, and Schindler (2014)

Table (5.1.3) demonstrates evident variations in the approaches regarding the study's goal, sample, and result. The relative studies' frequency indicates that high-tech small company studies use quantitative methodologies and approaches (Enjolras, Camargo, and Schmitt, 2019). In fact, qualitative approaches are used in very few articles. Therefore, without at least a basic understanding of quantitative methodologies, it can be challenging to study or research high-tech small firms and publish in relevant journals (Enjolras, Camargo, and Schmitt, 2019). Current research uses the quantitative technique to advance our understanding of technology orientation, strategic business resources, and innovation performance to fill in the knowledge gaps in this field. Consequently, the data was analyzed using AMOS and SPSS software to perform a descriptive analysis and an inferential statistic on high-tech small and medium enterprises in the UK.

5.4.3 Study Design

This study follows previous works on theoretical approaches, research methodology, and data collection methods. Previous studies have used quantitative methods and survey questionnaires to collect data on technology orientation-innovation performance-related studies. Table 5.1.5 lists some of the earlier studies on which this research study is based.

Table 5.1.5 Methodology of previous studies

Study	Method	Tool
Gatignon and Xuereb (1997)	Quantitative	Survey Questionnaire
Caroline Derozier, (2003)	Quantitative	Survey Questionnaire
Zhou <i>et al</i> , (2005)	Quantitative	Survey Questionnaire

Al-Ansari, Altalib, and Sardoh, (2013)	Quantitative	Survey Questionnaire
Chen <i>et al</i> , (2014)	Quantitative	Survey Questionnaire
Rezazadeh, Karami, and Karami, (2016)	Quantitative	Survey Questionnaire
Saqib, Zarine, and Udin, (2018)	Quantitative	Survey Questionnaire
Adams, Freitas, and Fontana, (2019)	Quantitative	Survey Questionnaire

5.4.4 Data Collection Methods

In the field of management research, there are various methods for collecting data (Saunders, Lewis, and Thornhill, 2009; 2019). The most relevant thing is choosing the method that matches the research philosophy and approach (Ghauri, Grønhaug, and Strange, 2020). Additionally, scholars may adopt a mixture of data collection methods in one research. According to Saunders, Lewis, and Thornhill, (2009), answering research questions and achieving research objectives, not the name of a particular technique, is the most important thing. Below is a list and explanation of research strategies mentioned by (Saunders, Lewis, and Thornhill, 2009).

First, experiments are an orderly procedure conducted to test a hypothesis. The experiment technique examines causal relationships, such as whether a researcher changes some variables and observes their influence on other variables. The variables that the researcher changes are called the independent variables, while the variables that change because of the alteration are called dependent variables (Saunders, Lewis, and Thornhill, 2009). An advantage of using an experiment is examining causal relationships that just observations cannot investigate. Also, it can be adapted to different subject areas like sociology, psychology, agriculture, and medical research. However, the disadvantages of experiments are that they require much time and are expensive.

Second, a case study technique is defined by (Saunders, Lewis, and Thornhill, 2009 2019) as a systematic way of researching to account for the complexity and depth of one or more cases. This technique answers what, how, and why questions. A case study might be interesting if a researcher wishes to gain a deeper understanding of research (Yin, 2009). Third, another technique is action research and was developed in 1946. Management researchers have understood it in different ways. This process is a systematic, reflective, and cooperative way of progressive problem-solving (Saunders, Lewis, and Thornhill, 2009).

Fourth, grounded theory is a systematic approach to analysing, explaining, and theorising everyday experiences, and it is viewed as theory-building through a combination of deduction and induction (Saunders, Lewis, and Thornhill, 2009). Fifth, ethnography derives from the subject of anthropology. It is the systematic study of people and cultures. The research process requires a response to change that is not strict. Therefore, the researcher will continuously develop new thought patterns about what is being observed. This approach consumes much time, so it is unsuitable if a researcher is constrained by time (Blumberg, Cooper, and Schindler, 2014).

Sixth, archival research involves systematic search, selection, and analysis of data collected by others, also called secondary data (Saunders, Lewis, and Thornhill, 2009). Furthermore, these data are used by researchers to conduct their studies (Johnson and Gill, 2010). Archival research enables researchers to point their research questions to previously executed activities. The technique is advantageous because there may be insufficient information to achieve research objectives or answer research questions (Saunders, Lewis, and Thornhill, 2009). Thus, secondary data will be the most vital element. Researchers should consider this technique when designing their research to use data (Bougie, 2010; Sekaran, 2011). Seventh, the survey is the systematic collection of information from a sample of people from a larger population. This technique is adopted for this research and needs to be examined in more detail.

5.4.5 Surveys

This technique is popular among management and business research researchers for different reasons. This technique is economical and suitable for collecting a large amount of data by targeting and using a questionnaire administered to a large population (Nagaraju, 2015). Survey methods are used for two primary purposes in management and business research. The first purpose is to find an accurate representation of the phenomena being researched through descriptive surveys, and the second is to provide the presence of a relationship between variables through analytical surveys. One of the main aims of this study is to determine the relationship between technology orientation and innovation performance. Therefore, a survey method is suitable for collecting data (Nagaraju, 2015).

This method gives considerable control over time and cost, as research findings could be generalised to the larger population through suitable sampling techniques, such as descriptive and inferential statistics (Sekaran and Bougie, 2010). Nevertheless, these methods have limitations as they cannot be used to examine phenomena in detail. The data gathered is self-reported, which could be biased, especially if the needed information is sensitive. Some of the limitations of this method consist of internal validity, external validity, and reliability (Saunders, 2012). A systematic process must be observed to overcome these limitations, and the questionnaire must be developed following the established procedures. The questionnaire must be tested for reliability and validity within the target group as it must reach the targeted participants and measure what it should (Nagaraju, 2015).

Adopting a survey approach allows researchers to use three popular tools for collecting data (Priest and Hallebone, 2009; Saunders, Lewis, and Thornhill, 2009). Firstly, the questionnaire is the most popular tool sent by post or electronically (Sekaran and Bougie, 2010). Secondly, structured observations are most frequently related to firms and research methods. Thirdly, structured interviews are conducted in which respondents are asked standardised questions. However, Barratt *et al.* (2011) noted some issues with using questionnaires. For example, suppose the questionnaire is long or unfamiliar with

the research topic. In that case, the respondents may become bored and not completely answer the questions, thus resulting in a low response rate.

Wall and Stokes (2014) state that there are three ways to conduct a questionnaire: Conducting face-to-face questionnaires, postal questionnaires, and email and online questionnaires. Nevertheless, questionnaires are not only a data collection tool used by researchers when they adopt a survey strategy, but they represent an excellent method to break down the main topic of the research into various parts and arrange the answers to these questions. In total, the results should meet the research objectives. According to (Cooper and Schindler, 2008), a standard method for quantitative research is survey measurement. Thus, a survey method is typical for collecting primary quantitative data to examine a causal relationship. Surveys were also used to generalise the results to the population because this approach allows researchers to select samples from a population and ensure this sample represents the target population. There are advantages of using surveys, such as obtaining a general idea of how people feel, which can be controlled (Coryn, 2007; Hair *et al.*, 2007).

Furthermore, surveys are easy to develop and contain a comprehensive set of items representing the topic of interest. Convergent and discriminant validity techniques are crucial to determine the adequacy of such measures (Mason and Bramble, 1989). Furthermore, multi-item scales and survey techniques help measure current conditions within a firm with a high level of specificity (Lyon, Lumpkin and Dess, 2000). The scale items that have forced-choice responses can contribute to greater measurement validity. In addition, the survey technique can efficiently collect large amounts of data at a relatively low cost and can be subjected to statistical analysis (Saunders, Lewis and Thornhill, 2009; Karami, 2011). Therefore, this research employs a survey technique as the research strategy, which is quite often used in management and business research (Hallebone and Priest, 2009). Thus, the researcher used the survey to explore the role of strategic firm resources in the relationship between technological orientation and innovation performance in the UK's high-tech small- and medium-sized enterprises sector.

5.4.6 Research Sample Selection

Choosing a sample to distribute the survey questionnaire and conduct the interviews is necessary, as the researcher cannot reach all respondents because of the researcher's limitations regarding access, money, and time to all potential respondents (Saunders, Lewis, and Thornhill, 2009). The SME population of the high-tech sectors in the UK were chosen to achieve the purpose of the research. Industry sectors are categorised in the UK as high-tech or low-tech, based on a "Standard Industry Classification" (SIC). High-technology SMEs are firms with advanced capabilities and knowledge in technology, an above-average proportion of scientists, above-average R&D intensity, technicians, and professional engineers in the labour force (Butchart, 1987; Crick and Spence, 2005).

Various criteria sometimes define high-technology firms. Industry-based researchers have equated high technology firms with organisations involved with innovation (Malecki, 1985; Steenhuis and De Bruijn, 2006a). Moreover, firm-based researchers have equated high technology with small research-based firms (Steenhuis and de Bruijn, 2006b, Bullock, 1983). Other studies have also classified high technology based on product and life cycle. High-tech SMEs in the UK were chosen due to their importance to the growth of the UK economy. Thus, this sector was an essential environment to research how different financial and technological resources could determine whether this high-technology SME could achieve innovative performance.

Furthermore, SMEs sometimes need external resources to increase their ability to grow, compete, survive, and achieve innovation performance in a rapidly changing environment, as explained in chapter four of the literature review. Based on SIC classification, FAME and Companies House Directory provide the researcher with a list of registered high-tech SMEs in the UK. The sample was framed and then reduced to focus on high-technology SMEs operating in information technology, computer manufacturing, software development, and telecommunications. This decision was made due to little research investigating how managers of these technology-oriented firms can use their resources and influence their innovation goals.

5.4.7 Internal and External Validity in Quantitative Research

Internal and external validity was checked using the quantitative strategy adopted for this research. According to LeCompte and Goetz (1982), internal validity considers whether a good match exists between the researcher's observations (data) and the theoretical ideas they develop. Internal validity is a particular strength of qualitative research because transcripts of interviews, especially if the participants confirm them, provide a basis for checking the level of unity between concepts and observations. On the other hand, external validity refers to the degree to which the researcher can generalise the findings across a social setting (Guba and Lincoln, 1994; LeCompte and Goetz, 1982).

5.4.8 Sources of Data

This research focused on the SME population of the high-tech industry in the UK. Industry sectors are classified in the UK as high-tech or low-tech, based on a "Standard Industry Classification" (SIC). The Financial Analysis Makes Easy (FAME) database provides the researcher with a list of registered high-tech SMEs in the UK based on previous classifications. The sample was framed and then narrowed down to focus on high-tech SMEs operating in (Business and domestic software development, manufacture of computers, Computer programming, Telecommunications and Information technology and computer service activities). These industries were selected due to little research examining firms' resources and their effect on the relationship between technology orientation and innovation performance in these industries (Hsu and Wang, 2012; Robert, 2015; Seo *et al.*, 2015; Tzokas *et al.*, 2015). SMEs in the UK were chosen because of their importance in the economy (Nicholas, Ledwith, & Perks, 2011). In addition, high-tech SMEs are "generally characterised as SMEs with an educated workforce, technological capabilities, and the ability to adapt quickly to rapidly changing environments" (Crick and Spence, 2005, p. 168). Also, the UK is a leading exporter of high-tech products and services.

5.5 Sampling

Sampling plays a significant role in the research process. According to Onwuegbuzie and Collins (2017), sampling design is a fundamental component of the research process. The inappropriate sampling design could lead to a lack of legitimation in the subsequent interpretation. The population of this research is small, high-tech businesses in the UK. The section below will entail the specific sampling strategies in this doctoral research.

5.5.1 Sampling Criteria

The sampling criteria state the specific characteristics that must be possessed by the elements in the population to be included in the research (Denzin and Lincoln, 2011; 2013). According to Burns and Grove (2010), the characteristics for inclusion delimit the research population of interest. Therefore, to meet the aims and objectives of this study, the FAME database was used to select small high-tech firms that fall under the Information technology and Telecommunications category. For an IT high-tech business to be included in this study, it must have met all the following features:

- 1) The business selected must be an IT and telecommunications high-tech business
- 2) Must be operating in the United Kingdom
- 3) it should be a small or medium-sized enterprise

5.5.2 Sample Frame

A sample frame is a subset of the population from which the sample size is selected for a study (Kumar, 2014). A study's sample selection depends on the population's size, characteristics, cost, and degree of accuracy needed (Salant and Dillman, 1994). One condition for selecting a sample in a study is to have a defined and narrowed target of the population under examination. Since the population for this study is all IT and telecommunications firms operating in the UK, the sample frame for this study is the firms found in the Fame database at the time of the research and met the sampling criteria indicated above. In total, the five sectors selected had a total of 9,256 SMEs (Business and domestic software development: 1388, Manufacture of computers, electronic and

optical products firms: 873, Computer programming, consultancy, and related activities firms: 4320 Telecommunications firms: 790 and Information technology and computer service activities firms 1885). Moreover, they have met the sampling criteria for inclusion in this study. Hence, the sample frame for this study is 9,256 SMEs.

5.5.3 Sampling Technique

Sampling is the process by which a suitably reasonable number of individuals or research elements are selected and studied to establish a research outcome regarding the entire population under consideration for a study (Frey & Burmaster, 1999). Sampling allows researchers to draw conclusions about the population by selecting a unit representative of the population (Maylor, Blackmon and Huemann, 2017). Sampling is the method by which the population sample is selected to represent the entire population for a study. There are two principal types of sampling: probability and non-probability (Saunders, Lewis, and Thornhill, 2009; Blumberg, Cooper, and Schindler, 2014; Maylor, Blackmon and Huemann, 2017). Probability sampling means that all the elements in the population have the same probability or chance of being included in the sample (Saunders, Lewis, and Thornhill, 2009; Blumberg, Cooper, and Schindler, 2014). Typical techniques applied in previous research are simple random, stratified random, systematic, and cluster. Non-probability sampling has no assurance that every element has some chance of being included in the sample. In other words, the elements do not have a known or predetermined chance to be selected in the sample. Typical techniques applied in previous research are purposive, quota, convenience, and snowball (Bryman and Bell, 2011; Blumberg, Cooper, and Schindler, 2014; Saunders, Lewis, and Thornhill, 2019). Figure 5.4 shows the techniques of the two sampling methods (i.e., probability and non-probability).

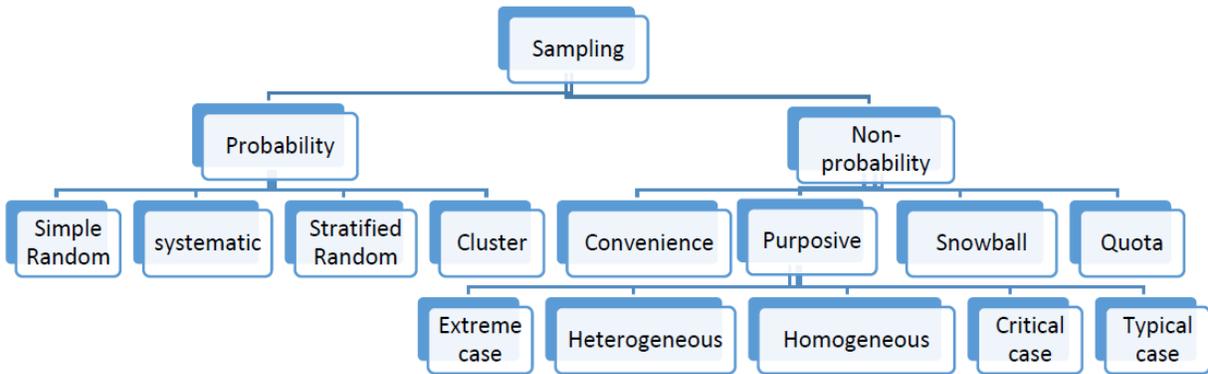


Figure 5.4 Sampling Types and Techniques

Source: Saunders, Lewis, and Thornhill (2019)

Probability sampling or representative sampling is most associated with survey-based research strategies. Each population unit has the same chance to be selected in this sampling category, and there is an equal probability of selection (Sekaran and Bougie, 2010; Saunders, Lewis, and Thornhill, 2019). Four main techniques can be used to select a probability sample, as shown in the figure (5.4),

Non-probability sampling is sometimes called non-random sampling, and the researcher selects some units purposefully of the population for research (Flint *et al.*, 2012). Some business and management studies research questions, objectives, and the strategy that has been developed may dictate non-probability sampling to answer the research questions and meet the research objectives. Five main techniques are used to select a non-probability sample, as shown in Figure (5.4) (Saunders, Lewis, and Thornhill, 2009). Explaining the stratified random sampling technique used in this research is essential.

This technique has many advantages; for example, the population can be classified into various categories; for instance, a population of adults includes both sexes and the employed and unemployed (Karami, 2011). It is possible to use this technique when the population is non-uniform. Based on this technique, the population can be classified into 2 or 3 strata, and then samples can be randomly or systematically selected from each stratum (Moore, 2009). Therefore, systematic or simple random sampling shares many advantages and disadvantages. Stratified random sampling is more likely to be

representative, and the most essential factor is that the researcher should ensure that each of the strata is represented proportionally within their sample.

Researchers such as Saunders, Lewis, and Thornhill (2009) posited that stratified random sampling is reliable, and samples can be stratified using more than one characteristic. In this study unit, the population was chosen by using stratified sampling. A stratified sampling technique was used to select the sample for this study. This technique allows the selection of a sample from high-tech SMEs, which are more likely to represent the population of high-tech SMEs in the UK, which has many companies. The sample is framed based on SIC codes to identify the companies.

5.5.4 Sample Size Determination

A sample size is a number selected representative of the population from which data is collected for a study (Frey & Burmaster, 1999). For the quantitative data collection, a sample size for the firms for each category was determined using a sample size determination formula developed by Yamane (1967) as follows: $S = N / [1 + N (e^2)]$ Where: S = sample size, N= target population, e = marginal error (degree of freedom = 0.05 (5%)). Table 5.2 below shows the details and calculations of the sample size for each industry sector.

Table 5.2 Sample Size Determination

Industry sectors	Sample Frame (Population Size)	Calculating the respondent sample size	The sample size
Business and domestic software development	1388	$1388 / (1 + 1388 * 0.05^2)$ =310	310
Manufacture of computers, electronic and optical products	873	$873 / (1 + 875 * 0.05^2)$ =274	274
Computer programming,	4320	$4320 / (1 + 4320 * 0.05^2)$ =366	366

consultancy, and related activities			
Telecommunications	790	$790 / (1 + 790 * 0.05^2)$ =266	266
Information technology and computer service activities	1885	$1885 / (1 + 1885 * 0.05^2)$ =330	330
Total	N=9256		n= 1,546

Based on the sample size determination formula (see Table 5.2), the sample size for the quantitative data collection was 1,546. Of the 1546 self-administered questionnaires sent out in January 2022, 141 fully completed questionnaires were retrieved, generating a response rate of 9.1%. The study did not achieve a high response rate because many managers did not want to complete the questionnaire, and some email addresses were no longer functioning. However, 141 respondents are still good enough for quantitative analysis.

5.5.5 The Sampling Procedure

The names and contacts of the Managers were obtained from the FAME (Financial Analysis Made Easy) database to identify which CEO/Manager to select from each stratum for the survey, which has a list of the high-tech SMEs in the UK. The names of the CEO/Managers were fed into a Microsoft Excel Spreadsheet and were first sorted in alphabetical order. The Microsoft Excel RAND Function was used to select a CEO/Manager from each stratum. The RAND Function is: =RAND BETWEEN (1, n), where n represents the sample frame of each stratum. This function was used to generate random numbers ranging from 1 to 1388. For example, the Excel command for Business and domestic software development-SMEs is: =RANDBETWEEN (1, 1388). The random numbers generated, which also corresponded with the names of the SMEs in a stratum, were then re-arranged in ascending order with the help of Microsoft Excel. Generating random numbers for each stratum provides a fair chance for each SME to be selected. Based on the sample frame of each stratum, the SMEs were identified in the order in

which they appeared. For example, in group one, Business and Domestic Software Development, the first 310 out of the 1,388 SME CEOs/Managers of this Business and domestic software development were selected to be involved in the study. The exact process was used for each group, which brought the total sample size to 1546 SMEs contacted for the final data collection. In addition, table (5.2) above illustrates how the research sample has been chosen carefully to cover the entire society. Therefore, the current sample is considered a representative sample of high-tech SMEs in the UK.

5.5.6 Data Collection Instrument

This study used an online questionnaire survey method to collect data. Some of the critical concerns related to the survey method using a questionnaire as a data collection instrument are population and sample size, the design of the questionnaire, piloting of the questionnaire, administration of the questionnaire for the primary data collection and non-response bias, which are discussed in the following sections.

5.5.7 Developing the Questionnaire

The researcher reviewed much literature on technology orientation, strategic firm resources, and innovation performance. This study's conceptual framework and research hypotheses were developed based on prior related research. After the research hypothesis and conceptual framework were developed, choosing suitable measurements for research variables and designing the questionnaire became necessary. Therefore, prior academic theory and literature were used to choose and select items for measuring variables.

However, research measurements have been adopted from considerable research due to their high reliability and validity. Specific care has been taken to apply the items to the target sample. The questionnaires were designed in eight sections (Appendix D). Specific rules that the researcher should follow are to avoid terms that are not clear in questions, avoid loaded questions which might lead the participant to answer the question in one direction, avoid long questions, avoid questions that include negatives and avoid asking two questions in one question (Bell & Bryman, 2007; Bryman and Bell, 2007). The

presentation of the questionnaire used throughout the data collection process is also crucial in enhancing the response rate. The length of the questionnaire, the order in which the questions are asked, the number of questions, anonymity and confidentiality of the respondents, user-friendliness, professional cover letter on a letterhead of the organisation, and offer of incentive if they participate in the survey, are some of the vital aspects of presentations (Dillman, 2007).

The questionnaire used for this research considered the points mentioned earlier from the design stage to administration. Cover letters were printed on Business School, University of Wolverhampton, on headed letter paper, and addressed to individuals. (See appendix A). The cover letter gave a brief background of the study, clearly stating the research objectives, the importance of their participation and their contribution to knowledge by participating in the survey. It also explained the confidentiality regulations followed, their voluntary participation and the incentives given for their participation. The questionnaire had nineteen pages, including a cover page, and the research topic was mentioned on the top of the cover page in bold. The participation/consent information sheet was attached to the questionnaire. It mentioned the purpose of the study, the benefits of the study, confidentiality regulations followed at the University of Wolverhampton and the respondent's right to withdraw at any time. Contact information about the research, including email addresses and phone numbers, was given for participants to contact if they had any concerns or questions regarding the study and questionnaire.

The questionnaire contained 26 questions in total. The questionnaire is divided into eight sections. The first section (A) began by requesting information about the organisation (Business profile). The following section (B) asked for personal information from the respondents. The following section (C) explored technology orientation, and sections (D, E, F, and G) explored strategic firm resources and one output variable (Innovation performance). The questionnaire ends by thanking the participants. It asked whether they wanted an executive report on the research. The researcher followed the exact format when designing the web-based questionnaire. JISC, a website that provides the tools to create and host the questionnaire, was used to administer the web-based questionnaire.

5.6 Data Collection

Data collection is the next step after deciding on the target sample and finalising the data collection technique. This study used a self-administered questionnaire to gather data from the high-tech firms operating in the UK. According to Denscombe (2008), the self-administered questionnaire can be conducted cheaper and quicker than other data collection methods such as experiments and observations. Furthermore, the data gathered through surveys are easy to analyse (Nagarajan, 2016). Thus, the quantitative data was collected through a cross-sectional approach by sending the survey questionnaire to CEOs or senior managers of firms. As discussed earlier, the researcher executed a questionnaire survey using the stratified sampling method to approach these firms. The questionnaire was designed on the JISC online survey platform (<https://admin.onlinesurveys.ac.uk/>), an online research service provider in the UK. One good thing about the program is that it has an email service that can send messages to the participants. The messages were typed with the letter of the university embedded, and they were addressed to the different participants by their names. The e-mail stated the study's purpose and its potential contribution to the development of their businesses. It also highlighted the anonymity of the information provided and confidentiality terms. The questionnaire was kept short. To ensure the samples were high-tech firms, a definition of high-tech SMEs was provided in the questionnaire (see Appendix D).

5.6.1 Piloting and Screening

A pilot study is a way to predict a suitable sample size and improve the study design by conducting a small-scale initial survey before carrying out a full-scale survey. The pilot study was conducted on a minor member of the same population to investigate the contents and context of the research questionnaire's reliance on previous related studies, relevant theories, and how practitioners understand things. A pilot study helps the researcher to get a total depiction of the developed survey questionnaire and its validity. However, this research was carried out in a focus group, and the target sample was ten people at Wolverhampton Business School and 10 CEOs and managers of high-tech SMEs. Both academics and practitioners provided constructive advice and comments,

which improved the structure of the constructed questionnaire in terms of questionnaire contents and context. Regarding the questionnaire's ambiguity, many questions were reformatted and amended to match the nature of SMEs and make them more transparent and understandable. After the piloting and screening stage, the email questionnaire was sent to 1546 SMEs. Days after sending the email, few responses were achieved. Also, a few calls were made, and more emails were sent weeks afterwards. To improve the response rate, the professional social network LinkedIn and other directories that contain details of firms, such as companies' house directories and endole, was used to contact CEOs and managers of these firms. In total, 171 questionnaires were returned. Before the empirical analysis, data was cleaned to remove inaccurate respondents from the final sample, either because there were incomplete or inaccurate responses in the questionnaire or the number of employees was more than the criteria of UK SMEs. The survey response is summarised in Table 5.3.

Table 5.3 Summary of responses to the survey questionnaire

Questionnaire Sent	No. of companies
Number of companies contacted – Online	1546
Number of Participants/Respondents	171
Response rate (per cent)	9.1
Responses with extensive missing data and non-SMEs	30
Final Sample	141

5.6.2 Ethical Considerations

Research involving humans must abide by specific ethical standards to protect subjects from harm (Jonsen, 1991). Ethical considerations in research suggest the understanding that all stakeholders involved in a piece of research should be dealt with using the utmost care (Denscombe, 2010). These stakeholders usually include the research participants, the researcher, and the funding institution. According to Gregory (2003), when humans

are used in research as participants, utmost care must be observed to protect the rights and dignities of those participants. Research has provided empirical evidence that high-technology small firms care about their reputation and place more value on preserving their intellectual property (Comino, Manenti, and Thumm, 2015).

Therefore, conducting quantitative research based on a survey with high-tech managers requires addressing any likely ethical issues that may arise before, during, and after the research. Therefore, the following factors were considered in observing and ensuring ethical issues: 1. Free from harm– No physical or psychological harm was experienced during the research. The respondents and interviewees participated in the research at their place of convenience and safety. The questions were asked in simple words to ensure understanding, and the respondents and interviewees were asked to express themselves freely without any compulsion from the researcher. 2. Freedom to participate – The research participants were given the free will to participate in the research. Although access to participants was initiated through the stratified random sampling technique, potential participants were not forced to participate in the research. Their permission was sought, and they were allowed to exclude themselves from the research whenever they wanted. 3. Confidentiality – The research participants were assured that all information provided for this study shall be treated with the highest confidentiality and that it shall be used purely for an academic endeavour, and no financial gain shall be derived from it. Thus, they could not give their names orally or in writing. 4. Academic credibility – Where other researchers' ideas, knowledge, or materials were used, appropriate acknowledgements were given accordingly in the form of references.

The researcher followed ethical research considerations such as seeking consent, collecting sensitive information, maintaining confidentiality, avoiding bias, avoiding incorrect reporting, using appropriate research methodology, and the proper use of the research information was observed during the study. They will be maintained after that (Denscombe, 2010). This research was done using the highest ethical considerations and standards, bearing in mind that participant information and data are assets and give a competitive edge to high-tech firms. Such information would not be divulged to third parties without their consent. There will also be no disclosure of respondent identities in

any other academic endeavour, for instance, in a publication. The researcher first secured ethical approval from the Faculty Ethics Committee within the University of Wolverhampton to ensure this research met the ethical requirements. Ethical Committee approval for details is attached as Appendix A. Precisely, there were three primary ethical considerations in this research, including informed consent, confidentiality, and anonymity.

5.6.3 Informed Consent

Informed consent ensures that potential participants understand the research, such as research aims, organisers, and data (Ritchie, Lewis, & Elam, 2013). For the questionnaire survey, this research provided a detailed informed consent form at the beginning of the online questionnaire, which explained the purpose of this research and how the data will be processed. Written informed consent was implied via completing and returning the questionnaire. The researcher obtained informed consent by providing a letterhead form stating the purpose of the research, and respondents could opt out from participating if they did not want to. Although this research adopted the stratified sampling procedure to access the high-tech small businesses, the participation was based on voluntary principles. All the participants were allowed to exclude themselves from the research if they did not want to participate further.

5.6.4 Confidentiality and Anonymity

Confidentiality and anonymity are vital ethical practices for protecting the privacy of human subjects during the data collection and data management process (Allen, 2017; Kamanzi & Romania, 2019). Confidentiality stressed that identifiable information about the respondents collected during the research process would not be disclosed (Wiles *et al.*, 2008). Such information could be protected through various processes designed to anonymise it. In contrast, anonymity commonly refers to collecting data without gathering personal identifying information (Burns and Burns, 2008). It implies that the researcher or the readers cannot identify a given response with a specific respondent in the final report or paper. For the questionnaire survey, this research was conducted on an online

platform, which could guarantee anonymity (Buchanan and Hvizdak, 2009). Compared to traditional face-to-face contact, the online platform does not have to give participants' postal addresses or phone numbers. All participant survey responses were kept on the University OneDrive in this research. All the participants' responses were organised to ensure that any potentially identifying information was removed before data analysis. After the data analysis, the results were archived on a password-protected encrypted drive. Furthermore, the data collected would not be divulged to third parties without participants' consent. Also, respondent identities will not be disclosed in any other academic publication.

5.6.5 Variables Measurement

The conceptual model for this research comprises the effect of availability of resources, use of resources, network capability, and degree of openness on the relationship between technology orientation and innovation performance. All the items are Likert-type scales with a five-point response format from 1 = 'strongly disagree' to 5 = 'strongly agree' (See Appendix D).

Independent Variable (Table 5.4)

Technology orientation (TO) is the independent variable for the model to be tested. Following the seminal work done by (Gatignon and Xuereb, 1997), Some studies have used four dimensions to measure TO (Lee, Dedahanov, and Rhee., 2015; Zhou *et al.*, 2005; Li, 2005; Chen *et al.*, 2014). As those studies empirically validated it, this study also measured TO through four multi-item constructs (Lee, Dedahanov, and Rhee, 2015). The CEOs and Managers of the high-tech SMEs were asked to assess the firm's level of technology orientation on a five-point Likert scale (ranging from 1 = 'strongly disagree' to 5 = 'strongly agree'). For example, "The policy of our firm has always been to consider the most up-to-date production available".

Dependent Variable (Table 5.4)

For the model to be tested, innovation performance is the dependent variable. Based on the work done by (Reichstein and Salter, 2006; Oke *et al.*, 2007). As empirically validated by those studies, this study adapted measures from their research to measure innovation performance through nine multi-item constructs. The CEOs and Managers of the high-tech SMEs were asked to assess the firm's innovation performance on a five-point Likert scale. For example, " We often improve or revise existing products or services".

Mediating Variables (Table 5.4)

The conceptual model measures the mediating effects of the availability of strategic firm resources (technological resources, financial resources, networking capability and degree of openness). The reason for choosing these four variables has been explained in Chapter 1. This research relied on a previously validated scale developed by Lotegraaf, Vorhies, and Morgan (2004) and Kyriakopoulos, Hughes, and Hughes (2016) to measure the availability of technological resources. The respondents were asked to indicate their agreement with the four items on a five-point Likert scale. For example, "Our company has the technical and scientific personnel that make relevant discoveries."

This research relied on a previously validated scale developed by Adomako and Ahsan (2022) to measure financial resources. The respondents were asked to indicate their agreement with each of the five items on a five-point Likert scale. For example, "We are satisfied with the financial capital available for our business operations."

This research adapted a previously validated scale from Moller and Halinen (1999) and Gilsing and Nooteboom (2005) to measure networking capability. The respondents of high-tech SMEs indicated their agreement with each of the six items on a five-point Likert scale. For example, " We can explore and exploit the opportunities innovation networks contain."

Finally, the degree of openness was measured by adapting an instrument developed by Tsai (2009) and Brunswicker and Vanhaverbeke (2015). The respondents of high-tech SMEs indicated their agreement with each of the six items on a five-point Likert scale.

For example, “To what degree has our firm cooperated with suppliers of equipment, materials, components, or software?”.

This research relied on a previously validated scale developed by Carnes *et al.* (2017) and Sirmon, Hitt, Ireland (2007) to measure structuring, bundling, and leveraging. The respondents indicated their agreement with the nine items on a five-point Likert scale. For example, "Acquiring: Our organisation purchases tangible and intangible resources from strategic factor markets."

Control variables

Following previous studies on firm innovation (e.g., Deng, Hofman and Newman, 2013; Gast *et al.*, 2018), this research controlled a few variables which could potentially influence the relationship between the dependent and independent variables. These variables include firm size and firm age. Regarding the firm size, this research used the number of full-time employees to measure the firm size. Eddleston and Kellermanns (2007) noted that larger companies tend to have more slack resources to attribute to innovations. Moreover, firm age was measured by the years since a firm's foundation. The empirical results of Zahra, Neubaum, and Larrañeta (2007) indicated that older companies are less likely to devote numerous resources to innovation activities due to their strategic conservatism. Therefore, it is essential to control the industry in this study. Table (5.4) illustrates the research, including measurements used to design this questionnaire.

Table 5.4 Research used to design current research measurements

Technology Orientation	Lee, Dedahanov, and Rhee, (2015)
The policy of our firm has always been to consider the most up-to-date production available.	
We have a long tradition and a reputation in our industry of attempting to be first in trying new methods and equipment.	
We spend more than most firms in our industry on new product development.	
We devote additional resources to technological forecasting.	
Innovation Performance	Reichstein and Salter, (2006); Oke et al, (2007)
We often improve or revise existing products or services.	
We add new products or services to our existing ranges.	
We often reposition existing products or services.	
We often change the way we make products or deliver services.	
We introduce new or significantly improved processes for producing or supplying products (goods or services) which are new to our industry.	
We develop products or services that better meet the needs of customers than any other product or service currently available.	
We introduce new products/services to an existing market.	
We introduce new products/services to a new market.	
We develop innovations that make our prevailing product/service lines obsolete.	
Availability of strategic firm resources	
Financial Resources	Adomako and Ahsan, (2022)
We are satisfied with the financial capital available for our business operations.	
Our company has easy access to financial capital to support our operations.	
Our business operations are better financed than our key competitors.	
If we need more financial assistance for our business operations, we can easily obtain it.	
We can obtain financial resources at short notice to support business operations.	
(Technological Resources)	Iotegraaf, Vorhies, and Morgan (2004). Kyriakopoulos, Hughes, & Hughes (2016).
Our company has the technical and scientific knowledge and information relevant to the industry.	
Our company has new technical and scientific discoveries relevant to the industry.	
Our company has patented knowledge relevant to the industry.	
Our company has the technical and scientific personnel that make relevant discoveries.	
Structuring	Carnes et al., (2017)
Acquiring: Our organisation purchases tangible and intangible resources from strategic factor markets.	
Accumulating: Our organisation is committed to the internal development of tangible and intangible resources.	

Divesting: Our organisation sheds firm-controlled resources that do not add value to the firm in a way that is not harmful.
Bundling Carnes et al. (2017)
Stabilising: Our Organisation makes minor incremental improvements in existing capabilities, which is needed to maintain our firm's current capabilities level of proficiency.
Enriching: Our organisation extends current capabilities which are needed to improve a firm's current capabilities level of proficiency.
Pioneering: Our organisation creates capabilities new to the firm by re-combining apparently unrelated resources in novel ways and bundling new complementary resources together.
Leveraging Sirmon, Hitt and Ireland (2007)
Mobilising: Our organisation integrates resources from various sources.
Coordinating: Our organisation can mix resources from multiple internal and external sources and coordinate resource integration with external partners.
Deploying: Our organisation can implement resources in new product development as well as exploit and apply resources that reside within and outside the organisation into innovation activities
Networking capability (Moller and Halinen, 1999; Gilsing and Nooteboom, 2005)
We can explore and exploit the opportunities innovation networks contain
We have a strong ability to find, evaluate and select appropriate partners during the business process.
We maintain and cooperate with a larger number of partners.
We have had all kinds of partners, such as universities, research institutes, famous software companies, important suppliers, customers, and so on.
We have a strong ability to create and maintain dense ties with our partners.
We have established a high number of ties with partners relative to the total possible number of ties.
Degree of Openness (Tsai, 2009; Brunswicker and Vanhaverbeke, 2015)
To what degree has our firm cooperated with suppliers of equipment, materials, components, or software
To what degree has our firm cooperated with direct customers
To what degree has our firm cooperated with Indirect customers
To what degree has our firm cooperated with network partners
To what degree has our firm cooperated with universities/commercial laboratories/R&D enterprises
To what degree has our firm cooperated with intellectual property rights experts
Control Variables
Firm Size
Firm Age

5.6.6 Common Method Bias

Common Methods Bias Common method bias manifests when variable variance is partially attributable to the measurement method rather than the constructs the measures represent (Podsakoff *et al.*, 2003). Common method bias is a type of bias peculiar to a survey study, which is the measure of error that could threaten the validity of the conclusions drawn upon the statistical result of this research (Podsakoff, Mackenzie, and Podsakoff, 2012). This bias is investigated by observing the systematic percentage variance that could make the conclusions of a statistical result unsound (Bagozzi and Yi, 1990; Doty and Glick, 1998). A statistical or procedural measure can be used to test common method bias. Procedural measures are used to examine the approach of data collection and the instrument design. In contrast, the statistical method is used to test and control the influences of common method bias (Podsakoff *et al.*, 2003). As identified by Podsakoff *et al.* (2003), the measures for testing common method bias using the procedural method include: (1) Adopting the measures of the predictors and criterion variables from different sources; (2) Using temporal, proximal, psychological, or methodological separation of measurement; (3) Protect respondent anonymity and reduce evaluation apprehension; (4) Counterbalance question order and (5) Improve scale for the items. This study adopted two procedural methods (i.e., protecting the anonymity of respondents and improving the scale items) to test for common method bias. To protect respondents' anonymity, the cover letter attached to the questionnaire assured participants of the confidentiality of their responses. There will also be no disclosure of respondent identities in any other academic endeavour, such as in a publication. A pilot test was conducted on the survey instrument to ensure an improved scale for the measured items. This is to ensure the questions are explicit, brief, and concise. This study adopted Harman's single factor as a statistical method for testing for common method bias (Podsakoff and Organ, 1986; Aulakh and Gencturk, 2000). Therefore, all the measures of the variables considered in this research were loaded onto an exploratory factor analysis on SPSS to determine whether most of the variance could be accounted for by one general factor. The rationale is that if a substantial amount of common method bias is present, either (a) a single factor will emerge from the factor

analysis or (b) one general factor will account for most of the covariance among the measures (Podsakoff *et al.*, 2003; Meade *et al.*, 2007). In this study, factor analysis of all items revealed a 7-factor solution (in line with the number of constructs in this research). Therefore, common method bias was not a problem in this research.

5.6.7 Test for Normality

To test the hypotheses, several preliminary statistical verifications were carried out to check the normality of the data. The normality of the data was assessed by examining the skewness and the kurtosis figures known to affect the analysis of variances and covariances when using SEM. These values are presented in Table 5.5. As suggested by West *et al.*, (1995) and Aleshinloye *et al.*, (2019), values greater than 2 for skewness and greater than 7 for kurtosis indicate the presence of non-normality of data. The output of SPSS results showed that no item presented a skewness or kurtosis level higher than these thresholds, suggesting that the normality condition is satisfied.

Table 5.5 Table of Results for Normality Check

	N Statistic	Mean Statistic	Std Deviation Statistic	Skewness	Kurtosis		
					Std. Error	Statistic	Std. Error
Technology Orientation	141	4.3422	0.7656	-1.580	.204	2.895	.406
Financial Resources	141	3.0283	0.9849	-.224	.204	-0.450	.406
TechnologyResources	141	4.5301	0.7615	-2.056	.204	5.016	.406
Networking capability	141	3.9054	0.8112	-0.469	.204	-.581	.406
DegreeofOpenness	141	3.8002	0.9880	-0.686	.204	.029	.406
StructuringResources	141	3.9078	0.7949	-0.570	.204	.554	.406
BundlingResources	141	4.1418	0.7162	-1.141	.204	2.069	.406
LeveragingRes	141	4.2151	0.7183	-0.942	.204	1.039	.406

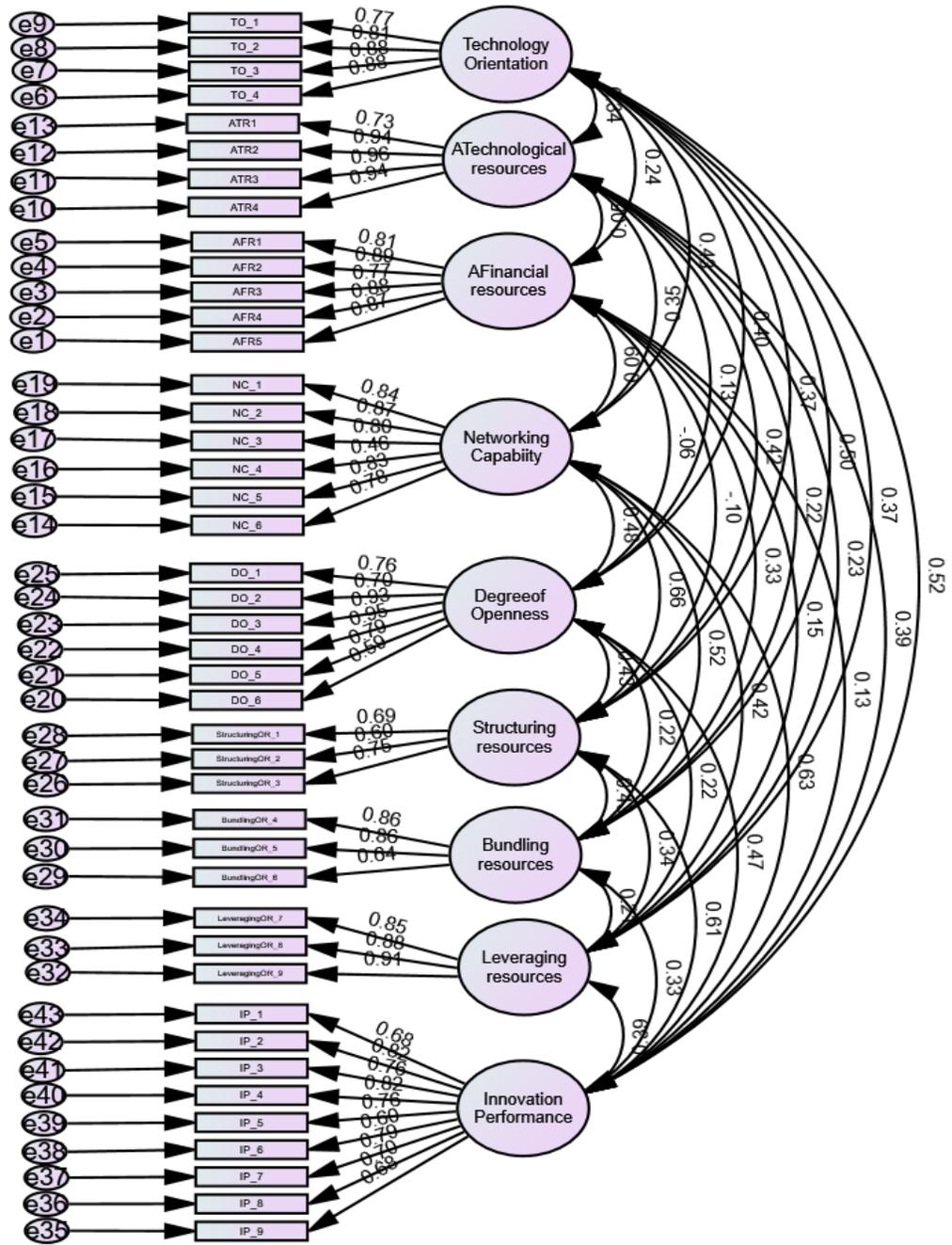
InnovPerformance	141	4.3073	0.6046	-0.738	.204	0.012	.406
Valid N (Listwise)	141						

5.7 Preliminary Statistical Analysis

5.7.1 Confirmatory Factory Analysis

Confirmatory Factor Analysis (CFA) was conducted to assess the factor loadings, construct correlations, and model fit indices. CFA was conducted with AMOS software (Version 29) to provide a confirmatory test for each construct that represents the technology orientation, availability of resources (Financial and technology resources), resource orchestration, networking capability and degree of openness. Observed variables or indicators measure each construct. As shown in Figure 5.5, all the variables are linked, and the construct items (observed variables for each exogenous construct) are represented in rectangular shapes. Two-headed arrows usually represent the covariance, whereas a one-headed arrow represents a causal relationship from a construct to an indicator.

Figure 5.5: The first CFA Model derived from preliminary analysis



5.7.2 Goodness of Fit Indices

The statistical estimation method applied in this study to estimate the model's parameters was maximum likelihood estimation (MLE). According to Hair *et al.* (2012), estimation is the most widely used method and is considered more efficient. Confirmatory factor analysis was used to examine the measurement models. Some fit indices should be considered to assess the model goodness-of-fit (Hair *et al.*, 2012). First, the ratio of the χ^2 statistic to its degree of freedom (χ^2/df) was used, with a value of less than 3 indicating an acceptable fit (Cheung and Rensvold, 2002; Hair *et al.*, 2010). Hair (2012) suggested the following indices to indicate acceptable fit: F". The first run of the CFA revealed the following results [$\chi^2/df= 2.235$; CFI=.799; TLI=.780; RMSEA=0.094]. These results indicated room for improvement to indicate a good measurement model fit of the data. Table 5.5 shows the level of acceptance obtained with the survey data.

Table 5.6 Model Fit Results for the Measurement Model

Model Fit	Model	Threshold/Acceptable value	Interpretation	References
CMIN/DF	2.235	<3	Achieved/Good fit	(Kline, 2004)
RMSEA	0.094	<0.08	Not achieved	(Maccallum <i>et al.</i> , 1996; Kenny <i>et al.</i> , 2014)
CFI	0.799	≥ 0.90	Not achieved	(Bentler, 1990)
TLI	0.780	≥ 0.90	Not achieved	(Bentler and Bonett, 1980)
IFI	0.802	≥ 0.90	Not achieved	(Hu and Bentler, 1990)
RMR	0.072	≤ 0.07	Not achieved	(Diamantop and Siguaw, 2000; Steiger, 2007)

The modification indices in AMOS provide information on the improvement in model fit. These modification indices suggest removing some indicators on some model parameters to improve its overall fit. Modification indices (MI) that reveal a very high covariance and demonstrate low regression weights should be deleted (Byrne, 2006; Hair *et al.*, 2012). Therefore, to ensure a good fit model, some indicators (NC4, DO6, UOR1, UOR2, UOR3, IP1, IP6, IP8, and IP9) were deleted from the initial measurement model. The process was to delete one indicator at a time and then re-estimate the model. Six indexes were used to assess the goodness of the model: the chi-square fit statistic, a measure of overall fit with non-significant χ^2 indicating good fit (Schermelleh-Engel *et al.*, 2003); the χ^2 divided by the degree of freedom, with a ratio of less than two signifying an acceptable fit (Kline, 2004; Schermelleh-Engel *et al.*, 2003); the comparative fit index (CFI) with CFI \geq 0.90 indicating an acceptable fit (Bentler, 1990); Tucker–Lewis Index (TLI) with TLI \geq 0.90 indicates an acceptable fit (Bentler, 1990). The root mean square of approximation (RMSEA), with RMSEA $<$ 0.08; indicating a good/acceptable fit; $0.08 <$ RMSEA $<$ 0.1 (Maccallum *et al.*, 1996; Kenny *et al.*, 2015); and root mean squared residual (RMR) with RMR \leq 0.070; (Diamantopoulos and Siguaw, 2000; Steiger, 2007); indicating a good/acceptable fit (Hu and Bentler, 1999). Table 5.6 shows the level of acceptance fit and the fit indices after the final improvement in model fit. Kline (2015) suggests that, at a minimum, the following indices should be reported: the model **chi-square**, the **RMSEA**, the **CFI** and the **SRMR**. The complete results are shown in Appendix A.

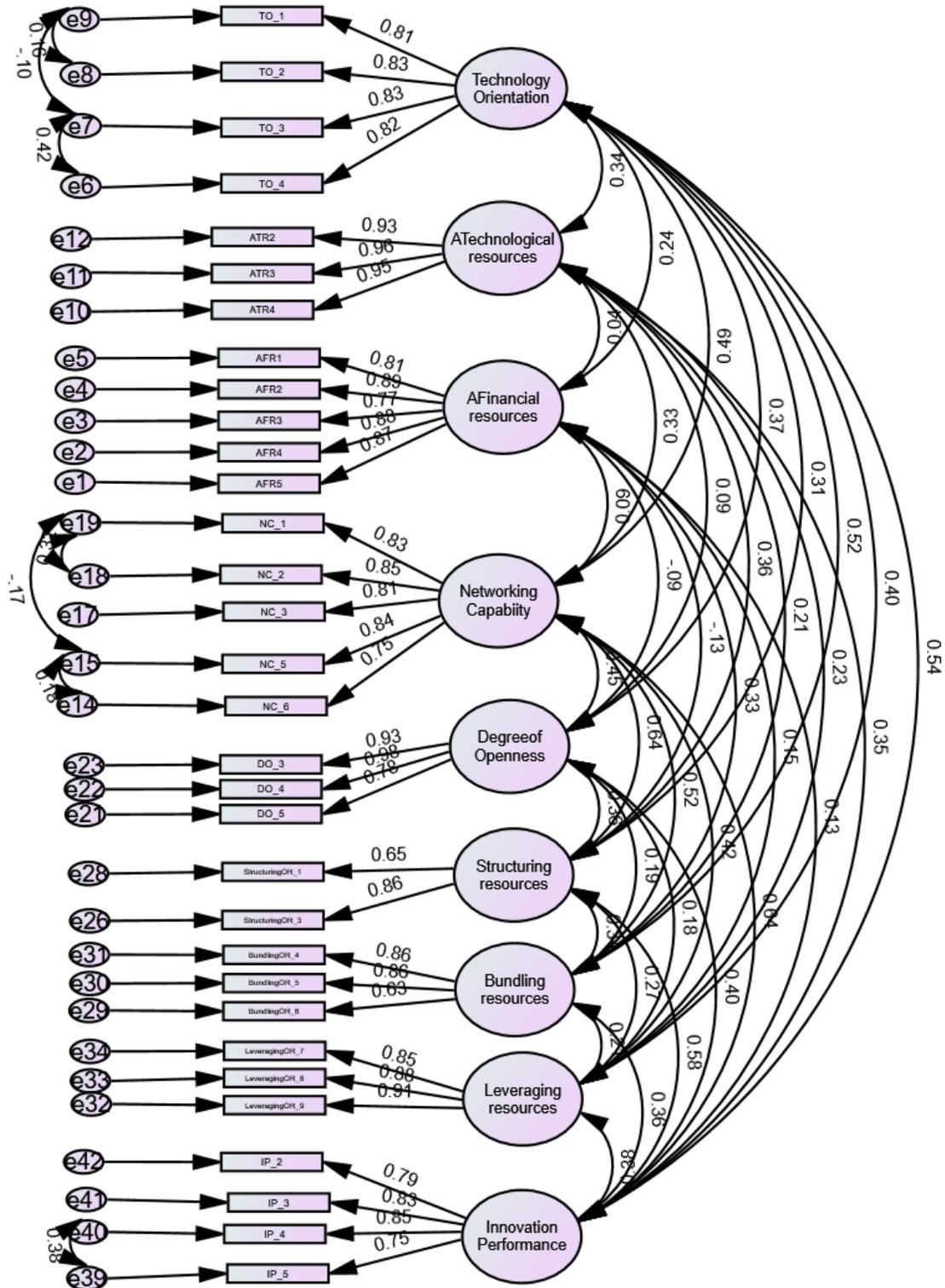
Table 5.7 Final Model Fit Results for the Measurement Model

Model Fit	Model	Threshold/Acceptable value	Interpretation	References
CMIN/DF	1.699	<3	Achieved/Good fit	(Kline, 2004)
RMSEA	0.071	<0.08	Achieved/Good fit	(Maccallum <i>et al</i> , 1996; Kenny <i>et al</i> , 2015)
CFI	0.919	≥0.90	Achieved/Good fit	(Bentler, 1990)
TLI	0.904	≥0.90	Achieved fit	(Bentler and Bonett, 1980)
IFI	0.920	≥0.90	Achieved/Good fit	(Hu and Bentler, 1999)
RMR/SRMR	0.065/0.0671	≤0.07	Achieved/Good fit	(Diamantop and Siguaw, 2000; Steiger, 2007)

Note. CFI = comparative fit index; IFI = incremental fit Index; RMSEA = root mean squared error of approximation.

Therefore, after checking the goodness of fit indices, the final refined model showed an acceptable model fit considering the number of items and the interrelationships of the constructs. The final measurement model is depicted in Figure 5.6. The fit indices indicated that the model provided an acceptable fit for the data. CMIN/DF, the ratio of model explanation to parsimony (chi-squares per degree of freedom) showed a good fit. A good fit was also demonstrated by a root-mean-square error of approximation (RMSEA) value of 0.071 (with below 0.080 customarily considered an acceptable fit) and a comparative fit index (CFI) of 0.919 (Hair *et al.*, 2012). Other fit indices, such as the incremental fit Index (IFI=0.920) and root mean squared residual (RMR=0.07), were also within acceptable ranges (Cheung and Rensvold, 2002; Hair *et al.*, 2012). Based on the results obtained from the factor analysis, only items with significant loadings were finally used in the regression analysis to test the study's hypotheses (Field, 2013).

Figure 5.6 The Final CFA Model



5.7.3 Validity and Reliability Measurement Analyses

The consistency and stability of measures that allow for replication of research are referred to as reliability (Burns and Burns, 2008; Tabachnick and Fidell, 2012). It assesses the degree of consistency between multiple measurements of a variable (Hair *et al.*, 2006). A commonly used measure of reliability is internal consistency. It assesses the consistency of variables (items) within a construct. Its underlying principle is that the indicators of the scale or individual items should all be measuring the same construct and, as a result, be highly inter-correlated (Nunnally and Bernstein, 1978; Field, 2013). The most used indicator of internal consistency is Cronbach's alpha (α) coefficient (i.e., reliability coefficient) (Field, 2013). Cronbach's alpha (α) assesses the consistency of the entire scale (Cronbach, 1951; Hair *et al.*, 2006; Field, 2013). This alpha (α) varies from 0 to 1, and a value of 0.6 or less generally means unsatisfactory internal consistency reliability (Malhotra, Nunan, and Birks, 2017). The generally preferred Cronbach's alpha (α) value is 0.70 (Cronbach, 1951; Pallant, 2010; Field, 2013). Since the reliability of a scale can vary depending on the sample, it is vital to ensure that each of the scales used is reliable. Additionally, it is vital to write items correctly before reliability analyses (Pallant, 2010; Burns and Burns, 2008). In the current research, all the internal reliability tests yielded coefficients above and above the threshold of Cronbach's $\alpha > 0.7$ (Cronbach, 1951; Field, 2013). Table 5.7 shows the results of average variance extracted (AVE) and composite reliability (CR)

Table 5.8 The results of composite reliability (CR) and average variance extracted (AVE)

	Cronbach's Alpha (CA)	Composite Reliability (CR)	Average Variance Extracted (AVE)
Technology Orientation	0.902	0.896	0.686
Availability of Financial Resources	0.923	0.925	0.712
Availability of technological resources	0.939	0.938	0.794
Networking Capability	0.892	0.912	0.676
Degree of Openness	0.908	0.917	0.693
Structuring of Resources	0.717	0.730	0.579
Bundling of Resources	0.811	0.831	0.626
Leveraging of Resources	0.912	0.913	0.778
Innovation Performance	0.911	0.895	0.589

Table 5.7 shows the results of reliability analyses and Fornell-Larcker coefficients for the Model. All the reliability coefficients for the measurement variables were above the threshold of Cronbach's $\alpha > 0.7$ (Cronbach, 1951; Hair *et al.*, 2010; Field, 2013; Bagozzi and Yi, 2017). The discriminant validity of the scales is assessed using a procedure outlined by Fornell and Larcker (1981). According to Fornell and Larcker (1981) and Hair *et al.* (2010), all the constructs demonstrated discriminant validity if the square root of AVE is always more significant than the largest latent variable correlation. Table 5.7

provides descriptive statistics of the square root of AVE and correlations. According to the testing results, the square roots of the AVE in each latent variable are larger than the largest corresponding squared inter-construct correlation. For example, the square root of AVE in the Leveraging of Resources is (0.882), greater than the largest corresponding squared inter-construct correlation (0.390). Therefore, this research's scale has good convergent and discriminant validity.

Table 5.9 Fornell-Lacker coefficients for the Model

	1	2	3	4	5	6	7	8	9
Leveraging of resources	0.882								
Technological Orientation	0.345	0.828							
Availability of Financial Resources	0.151	0.240	0.844						
Availability of Technological Resources	0.229	0.323	0.045	0.891					
Networking_Capability	0.433	0.416	0.092	0.359	0.822				
Degree of openness	0.191	0.389	-0.065	0.104	0.423	0.832			
Structuring of resources	0.268	0.254	-0.131	0.358	0.628	0.371	0.761		
Bundling of resources	0.208	0.491	0.326	0.211	0.538	0.206	0.339	0.791	
Innovation Performance	0.390	0.536	0.124	0.397	0.635	0.425	0.584	0.351	0.767

Note: The square roots of AVE are presented in bold font.

5.7.4 Conclusion

This chapter examined research design choices comprising the philosophy, research approach, research strategies, and data collection methods and procedures used in this research. This chapter analyses the general overview of the philosophical assumption, followed by the research design applied in this research. Positivism research applied the quantitative method to shape the research design process. Furthermore, the chapter discusses the population and sampling procedures for quantitative research. The sources of data, the design of the data collection instrument, and the data analysis and research tool are also addressed in this chapter. The measurement imperatives regarding validity and reliability were discussed. The ethical considerations that were observed during the study were also explained. In this research, the ontology is objective, the epistemology focuses on generalisations, axiology is independent of the data, the methodology is hypothetical-deductive, and the methods are statistical testing, survey research and literature. Having provided an in-depth understanding of the research design and the methods used in conducting this study, the next chapter deals with the systematic presentation and discussion of the quantitative research findings.

CHAPTER 6: QUANTITATIVE RESEARCH FINDINGS

6.1 Introduction

The preceding chapter discussed the research design and methodology. This chapter reports and discusses the results of the quantitative testing of the conceptual model. The results are based on the survey data from 141 high-tech SMEs in the United Kingdom. The chapter also discusses the correlation results and hypothesis concerning the proposed conceptual model. Additionally, the results are interpreted and discussed. The main goal of this chapter is to provide an in-depth discussion on the impact of the availability of resources, use of resources, networking capability and degree of openness on the relationship between technology orientation and innovation performance in UK high-technology SME businesses. Tables were used to aid the analysis of the data because they are practical illustrations depicting relations and trends. The following sections discuss the demographic analysis of respondents, the descriptive statistics of the variables in the model, the characteristics of the studied firms and inter-correlations among all the variables.

6.2 Demographic Analysis of Respondents

This section analyses the demographic characteristics of the respondents. These include gender distribution, the age of respondents, the role played in business, and educational status. Also, the businesses were analysed regarding their sectoral distribution, age, size and legal form.

6.2.1 Descriptive analysis

In this research, the data collected was entered into SPSS, and the results are presented in the following sections.

6.2.2 Demographic characteristics of respondents

This section analyses the demographic characteristics of the respondents. The demographic characteristics include gender distribution, the age of respondents, the

position in the firm, educational status, and total work experience. The following Table 6.1 presents the analysis of the demographic characteristics of the respondents and the business profile. The following table 6.1 presents the analysis of the demographic profile of the respondents.

Table 6.1 Demographic profile of the respondents

Demographic Variables	Items	Frequency	Percentage
Gender	Male	128	90.8
	Female	13	9.2
	Transgender	0	0
	Non-Binary	0	0
Age Distribution	20-29	1	0.7
	30-39	7	5.0
	40-49	31	21.9
	50-59	76	53.9
	60+	26	18.4
Position in the firm	CEO/MD	51	36.2
	Chief Operating officer	28	19.9
	Chief Finance Officer	7	5.0
	Chief Technology Officer	27	19.2
	IT Manager	2	1.4
	Product Manager	5	3.6
	Operations Manager	8	5.7
	Others	13	9.2
Level of Education	A level or less	18	12.77
	Batchelor	82	58.16
	Masters	33	23.4
	PhD	4	2.84
	Others	4	2.84
Total Work Experience	0-5	0	0
	6-10	1	0.7
	11-15	3	2.1
	16-19	15	10.6
	20 or more	122	86.5

6.2.3 Gender

Most respondents were male in researched High-tech SMEs, (90.8%) of the respondents are men, while (9.2 %) are women. In terms of gender, data analysis revealed that most executives and managerial positions are occupied by males in high-tech SMEs in the researched industry sectors, as shown in Table (6.1).

6.2.4 Age of the respondents

The age of respondents has been divided into five groups; the first group was (20- 29) years. (0.1%) of the respondents were in this age band. The second group was (30-39) years. (5.0%) of the respondents were in this age band. The third group was (40-49) years. (21.9 %) of the respondents were in this age band. The fourth group was (50-59). (53.9 %) of the respondents were in this age band. The fifth group was (60+), and 18.4% were in this group. Based on the information above, most of the managers of high-tech SMEs fall between 50 and 59. Table 6.1 shows the percentages of the respondents of different ages.

6.2.5 Managerial position of the respondents

This study's target sample was the top management in high-tech SMEs. Small and medium enterprises have a flat and flexible structure, which allows top management to be involved in all firm activity and decisions (Ghobadian and Gallear, 1997; Hudson *et al.*, 2001; Nicholas, Ledwith, & Perks, 2011). Managers of high-tech SMEs have been chosen because this study aims to determine how the availability and use of resources could affect technology orientation and innovation performance. Thus, the choice of managers could give an insight into how this is achieved.

Furthermore, this study used the managers' level within the company to investigate the managers' positions. It shows that (36.2%) of the respondents were CEOs/MDs in the researched firms. The descriptive analysis of the data reveals that (19.9 %) of the respondents were chief operating officers in high-tech SMEs, 3.6% were product managers, 5.0% were Chief finance officers, 1.4% were IT Managers, 5.7% were operation managers, chief technology officer/technical director were 19.2%. (9.2%) of the

respondents selected “other”. This option included positions like Founder, Head of Finance, Sales Director, Director of Enterprise Business, chairman, etc. Hence, based on the details of the respondents’ position data analysis revealed that many questionnaires in this study (51) were completed by the CEO/MD, who was completely involved and responsible for making the crucial decisions of using resources to enhance their technology orientation and investing in knowledge and building dynamic capabilities, enhancing the level of intellectual capital, and improving performance in the surveyed firms. Table (6.1) shows the managerial position of the respondents in the researched firms.

6.2.6 Level of Education

Education is one of the most essential factors in accessing a person’s knowledge and skills. Academic education is considered one of the most important indicators for measuring a considerable aspect of human capital (Grichnik *et al.*, 2014). Education is one of the most important factors for managers. Managers in SMEs with a formal education background can provide various innovative solutions for work problems. In addition, they are more likely to think differently or creatively. These people are qualified to lead and develop organisations in dynamic business environments. However, this study measured the academic education level using five options according to the UK educational system: A levels, bachelor’s degree, master’s degree, PhD, and others. The number of respondents who hold PhD degrees is (4) and Masters’ degrees are (33), the number of respondents who hold bachelor’s degrees is (82), the number of respondents who have A levels is (18) and others is (4). In line with Crick and Spence (2005), high-tech SMEs are characterised as SMEs with a well-educated workforce; the data analysis of the respondent’s level of education revealed that most of them were well-educated. Furthermore, table 6.1 illustrates the level of education and the academic degree.

6.2.7 Total work experience

Working experience is the level of skills and knowledge individuals own. It is accumulative skills, attitudes, know-how, and techniques. Scholars such as (Grichnik *et al.*, 2014) used a specific part of working experience, managerial experience, as an indicator to measure part of human capital in new firms. Total Working experience was measured by asking the respondents to indicate their total working experience band in years. The percentage of respondents who hold 6-10 years of working experience was (0.7%), the percentage of respondents who hold 11-15 years of working experience was (2.1%), and the respondents who hold 16-19 years of working experience were (10.6%). Finally, the respondents with 20 or more years of working experience were (86.5%). Most research respondents represent managers with a deep knowledge of their firm and its industry. Based on their total working experience.

6.3 Characteristics of the studied firms

This study investigated high-tech SMEs operating in the UK: business and domestic software development, computer manufacturing, electronic and optical products, information technology and computer services, computer programming, related activities, and telecommunications. This section on descriptive demographic information highlights the firms' characteristics such as their age, location, number of employees, business sector and legal form of firm. The results are presented in Table 6.2.

Table 6.2 Demographics of Firms (N=141)

Variables	Items	Frequency	Percentage
Age of firms	1971-1980	4	2.8
	1981-1990	15	10.6
	1991-2000	36	25.5
	2001-2010	47	33.3
	2011-2020	38	26.9
	2021-present	1	0.7
Location of firms	Southwest England	7	4.96
	Southeast England	26	18.4
	Northwest England	3	2.1
	Northeast England	1	0.7
	Yorkshire and the Humber	3	2.1
	West Midlands	16	11.3
	East Midlands	12	8.5
	London	43	30.4
	East of England	13	9.24
	Scotland	17	12.0
No of employees	0-9	17	12.1
	10-49	54	38.3
	50-249	70	49.6
Business sector	Software development	45	31.9
	Manufacture of computers	10	7.1
	Telecommunications	19	13.5
	Computer programming and services	16	11.3
	IT and computer service activities	51	36.2
Legal form of firm	Private limited Company	135	95.7
	Public Company	5	3.5
	Other	1	0.7

6.3.1 Age of firms

Collated data reveals that many SMEs in the Business and domestic software development, manufacture of computers, electronic and optical products, telecommunications, computer programming and related activities, information technology and computer services show that 4 (2.8%) of the firms were established between 1971 and 1980 while 15 (11.2%) of firms were established between 1981-1990 while 36 firms (25.5%) of the firms were established between the years 1991 to 2000. Also, 47 (32.5%) of the firms were established between 2001-2010. 47 (26.9%) of the firms were established between 2011-2020. Finally, only one firm was established in the year 2021.

6.3.2 Location of Firms

This research surveyed three sectors of the UK's high-tech, small and medium-sized enterprises. Regarding the geographical distribution of the SMEs, the data analysis results reveal that most firms (87.9%) were in England, and (12.1%) of the researched SMEs were in Scotland.

6.3.3 Number of employees

Data analysis shows that (38.3%) of the surveyed firms were small enterprises, and (49.6%) were medium-sized enterprises, while (12.1%) were micro.

6.3.4 Business Sector

This study focused on the researched business sectors in the UK, which operate in Business and domestic software development, manufacture of computers, electronic and optical products, telecommunications, computer programming and related activities, information technology and computer services. Data analysis of this research reveals that Business and domestic software development were (45) respondents, while the manufacture of computers, electronic and optical products were (4) respondents, Computer Programming, consultancy, and related activities were (10) respondents, and

Telecommunications were (19) respondents, information technology and computer services were (51) respondents, and respondents from firms operating in other sectors were (12).

6.3.5 Legal form of firm

Regarding legal form, the majority (95.7 percent) of the businesses that responded were private limited companies. 3.5 percent said they were public companies. Finally, only one firm chose another legal form.

6.4 Analysis of the Inter-Correlation Among the Variables

The correlation analysis indicates the relationship between the variables. Table 6.3 displays the key variables, means, and standard deviation correlations. For example, there is a moderately positive and significant correlation between the structuring, bundling leveraging and innovation performance ($r=0.497, p<0.01$) ($r=0.396, p<0.01$) and ($r=0.504, p<0.01$). A positive and significant correlation exists between the degree of openness and innovation performance ($r=0.473, p <0.01$). A positive and significant correlation exists between networking capability and innovation performance ($r=0.553, p<0.01$). There is also a moderately positive and significant correlation between technology orientation and availability of technological resources ($r=0.339, p<0.01$), technological orientation and availability of financial resources ($r=0.229, p<0.01$), technology orientation and networking capability ($r=0.379, p<0.01$), technological orientation and degree of openness ($r=0.379, p<0.01$).

Hence, H1 was supported. The result shows that a technology orientation is positively related to innovation performance.

Table 6.3 Correlations among all Variable

		M	SD	1	2	3	4	5	6	7	8	9	10	11
1	Technology Orientation	4.342	0.766	1										
2	Avail of Technological Resources	4.530	0.761	.339**	1									
3	Avail of Financial Resources	3.028	0.985	.229**	0.061	1								
4	Networking capability	3.905	0.811	.379**	.327**	0.092	1							
5	Degree of Openness	3.800	0.988	.379**	.176*	-0.006	.493**	1						
6	Innovation Performance	4.307	0.605	.487**	.372**	0.120	.553**	.473**	1					
7	Structuring	3.908	0.795	.333**	.363**	-0.071	.517**	.359**	.497**	1				
8	Bundling	4.142	0.716	.522**	.321**	.350**	.445**	.292**	.396**	.515**	1			
9	Leveraging	4.215	0.718	.586**	.431**	.296**	.566**	.379**	.504**	.510**	.790**	1		
10	Firm size	66.08	57.780	0.066	-0.016	.182*	-0.016	-0.074	0.061	0.108	0.075	0.087	1	
11	Firm Age	3.84	0.804	-0.121	0.107	0.074	0.034	-0.065	-0.066	-0.056	-0.048	-0.045	0.020	1

Note: N=141. Natural Logarithm of the number of full-time employees *p<0.05 ** P<0.01

*. Correlation is significant at the 0.01 level (2-tailed).

6.5 Results of Research Model Testing

This section reports regression analysis results from testing the hypotheses in Chapter 4. Based on the conceptual model of this research. The regression analyses were divided into two stages. In the first stage, a multiple regression was carried out to test the relationship between technology orientation and innovation performance and the mediating effect of the availability of technological resources, availability of financial resources, networking capability and degree of openness on the technology orientation and innovation performance relationship, that is hypothesis 1, 2, 3, 4, and 5. Secondly, this study further examined the mediating effect of structuring, bundling and leveraging on the relationship between the availability of technological resources, financial resources, networking capability, degree of openness, and Innovation performance, that is, hypothesis 6a,6b,6c, 7a,7b,7c, 8a, 8b, 8c, 9a, 9b, and 9c.

6.5.1 Regression Analysis and the Research Hypothesis

In this research, hierarchical multiple regression analysis is the principal statistical technique used for data analyses and for subsequently testing the study's hypotheses. Hierarchical multiple regression is a form of multiple linear regression analysis used to analyse the relationship between a single dependent variable and several independent variables (Aiken, 1991). Specifically, it is an extension of simple linear regression analysis, and it is used to assess the relationship between two or more independent variables and a single continuous dependent variable. The generic multiple linear regression equation is as follows: $\hat{Y} = b_0 + b_1 X_1 + b_2 X_2 + \dots + b_p X_p$, where \hat{Y} is the predicted or expected value of the dependent variable, X_1 through X_p are p distinct independent or predictor variables, b_0 is the value of Y when all of the independent variables (X_1 through X_p) are equal to zero, and b_1 through b_p are the estimated regression coefficients (LaMorte, 2016).

Tables 6.4 to 6.5.6 report the results of hierarchical multiple regression analyses executed to determine the single and combined effects of all variables on the innovation performance of small high-tech businesses. All assumptions must be met before carrying

out a hierarchical multiple regression check. The assumptions of linearity, homoscedasticity, unusual points, absence of multicollinearity, and normality of residuals were all met (Cohen *et al.*, 2013). All the regression coefficients for independent, mediating, and control variables are in the expected direction.

6.5.2 Effects of technology Orientation on innovation performance

This section examines the effect of technology orientation on innovation performance in high-technology SMEs in the United Kingdom. In line with the hypothesis, the study proposed that technology orientation positively correlates with innovation performance. Therefore, in this section, the study will test this hypothesis and assess the effect of technology orientation on innovation performance. This study's results show a positive correlation between technology orientation and innovation performance, and it is also statistically significant at a 5% level. As shown in Table 6.4, the important relationship between technology orientation and innovation performance aligns with most extant literature (Gatignion and Xuereb, 1997; Hsu, 2016; Ince *et al.*, 2016). The first stage tested the relationship between technology orientation and innovation performance. Hypothesis 1 argues that technology orientation has a positive effect on innovation performance. Table 6.3 presents the results of the regression analysis.

Table 6.4 Regression results for the relationship between technology orientation and innovation performance

	Innovation Performance	
	Model 1	Model 2
Control		
Variable		
Firm Size	0.069	0.032
Firm Age	0.060	0.027
Independent		
Variable		
Technology orientation		0.483**
R2	0.007	0.239
Adjusted R2	-0.007	0.222
F Value	0.498	14.321

Note: N=141; * $p < 0.05$ **; Standardised regression coefficients (β) are shown in each equation, ^aNatural Logarithm of the number of full-time employees.

As seen in Table 6.4, model 1 only included control variables, including firm size and firm age. In model 2, the independent variable, technology orientation, was positively and significantly associated with innovation performance ($\beta=0.483$, $p < 0.01$), which implies that a higher level of technology orientation could lead to more innovation performance. Furthermore, the F-value of this model was significant ($F(3,137) = 14.321$). The adjusted $R^2=0.222$ indicated that the model could explain 22.2% of the variance of innovation performance. The control variables have a combined marginal but insignificant effect on innovation performance with an adjusted R^2 of -0.007 (-0.7%).

The results reveal that technology orientation positively correlates with innovation performance, suggesting that higher technology orientation results in more remarkable innovation outcomes. Investing resources in innovation is viewed as the starting point of product innovation (Lee, Wu, and Pao, 2014). Particularly, continued development of technology internally or externally and investment in R&D allow firms to gain useful

external knowledge sources (Escribano, Fosfuri and Tribó, 2009), buy new machines, equipment, and software (Rosenbusch, Brinckmann and Bausch, 2011), or hire highly skilled employees (Escribano, Fosfuri and Tribó, 2009). This finding is consistent with previous studies, suggesting that a higher technology orientation can result in more excellent innovation performance (Liu and Chen, 2015; Qu and Mardani, 2023). For example, Qu and Mardani (2023) showed, examining high-tech firms in China, that investments in innovation are a prerequisite for creating new or improved products. Technology orientation is positively related to product innovation and, consequently, to new product performance. Liu and Chen (2015), while investigating 118 new product development cases, found that technology orientation is positively related to product innovativeness, which is consequently positively associated with new product performance. As such, technology orientation positively affects innovation performance, supporting hypothesis 1 (H1).

6.5.3 The mediating effects of the availability of technological resources between technology orientation and innovation performance

This study tested the mediating effects of the availability of technological resources between technology orientation and innovation performance. A mediating effect exists when the three conditions are satisfied (Baron and Kenny, 1986). First, the independent variable should be correlated with the dependent variable. Second, the independent variable and mediator are correlated. Third, as the mediating variable is added, the effect of the independent variable on the outcome variable must be significantly diminished or eliminated (Williams, Vandenberg, and Edwards, 2009). Hypothesis 2 proposed that the availability of technological resources mediates the relationship between technology orientation and innovation performance. Table 6.4.1 provides the testing results of mediation for the availability of technological resources via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is significantly associated with the dependent variable. The results show that the availability of technological resources was significantly and positively related to innovation performance ($\beta=0.483$, $p<0.001$). In model 2, the independent variable, technology

orientation, was regressed against the mediating variable, availability of technological resources ($\beta=0.249$, $p<0.001$). Therefore, technology orientation was associated with the availability of technological resources, which confirmed the second condition. Model 3 tested whether the relationship between technology orientation and innovation performance remained significant when the mediator, the availability of technological resources, was introduced into the initial relationship. The results showed that while the initial relationship between technology orientation and innovation performance continues to be significant ($\beta=0.249$, $p<0.001$), the effect of technology orientation on innovation performance decreased when the mediator was introduced (β decreased from 0.483 to 0.399). The control variables' overall combined effect is small and insignificant on innovation performance ($R^2 = 0.222$; $p \geq 0.05$).

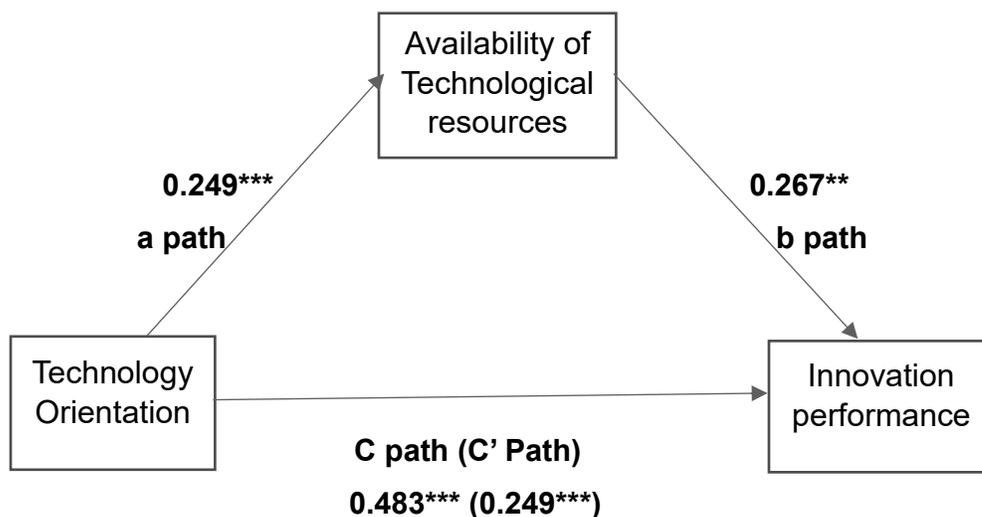
Table 6.4.1 Regression results for the mediating effect of availability of technological resources on the relationship between the technology orientation and innovation performance

	Innovation Performance	Availability of technological resources	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.000(0.032)	0.000(0.014)	0.000(0.028)
Firm Age	0.000(0.027)	0.004(0.382)	-0.001(-0.075)
Independent Variable			
Technology orientation	0.382***(0.483)	0.315***(0.249)	0.315***(0.399)
<i>Mediator</i>			
Availability of technological resources			0.212**(0.267)
R ²	0.239	0.259	0.292
Adjusted R2	0.222	0.243	0.271
F Value	14.321	15.967	14.003

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (β) and standardised regression (β) are shown in each equation; a Natural Logarithm of the number of full-time employees.

This research further calculated the indirect mediation effect and total effect. As shown in Figure 6.1, the impact of technology orientation on innovation performance is exerted via two routes. The first is the direct effect of the technology orientation on innovation performance (path c'). The second is the indirect effect (path ab=0.066, 0.249*0.267) on the availability of technological resources. The results show that the indirect mediation effect accounts for 13.8% of the total mediation effect (ab)/(c) (0.066/0.483), suggesting that the availability of technological resources partially and positively mediated the relationship between the technology orientation and innovation performance, which supports hypothesis 2. This finding is consistent with previous studies (Sedoglavich, 2012; Huang *et al.*, 2015). The high availability of technological resources enables high-tech SMEs to learn new knowledge and skills actively, accumulate necessary technologies, absorb them, and use them in the firm R&D activities to develop new products or services. The finding implies that technology orientation positively affected innovation performance through the availability of technological resources.

Figure 6.1 The Mediating effect of the availability of technology resources between technology orientation and innovation performance



*p<0.05 **p<0.01***p<0.001

c'= Indirect part between technological orientation to Innovation performance

a= Path from technology orientation to availability of technological resources

b= Path from the availability of technological resources to Innovation performance.

c= c' + a*b (Total path)

6.5.4 The mediating effects of the availability of financial resources between technology orientation and innovation performance

This study tested the mediating effects of the availability of financial resources between technology orientation and innovation performance. A mediating effect exists when the three conditions are satisfied (Baron and Kenny, 1986). Hypothesis 3 proposed that the availability of financial resources mediates the relationship between technology orientation and innovation performance. Table 6.4.2 provides the testing results of mediation for the availability of financial resources via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is significantly associated with the dependent variable. The results show that technology orientation was significantly and positively related to innovation performance ($\beta=0.483$, $p<0.001$). In model 2, the independent variable, technology orientation, was regressed against the mediating variable, availability of financial resources ($\beta=0.226$, $p<0.01$). Therefore, technology orientation was associated with the availability of financial resources, which confirmed the second condition. Model 3 tested whether the technology orientation and innovation performance remained significant when the mediator, the availability of financial resources, was introduced into the initial relationship. The results showed that while the initial relationship between technology orientation and innovation performance continues to be significant ($\beta=0.249$, $p<0.001$), the effect of technology orientation on innovation performance does not significantly decrease when the mediator was introduced (β decreased from 0.483 to 0.482). The control variables' overall combined effect is small and insignificant on innovation performance ($R^2=0.222$; $p\geq 0.05$).

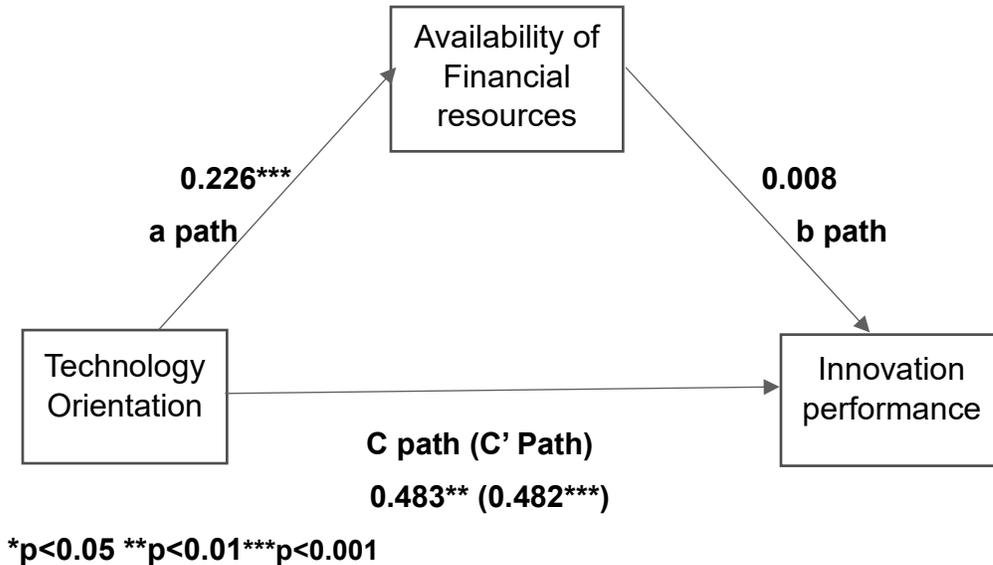
Table 6.4.2 Results for the mediating effect of availability of financial resources on the relationship between the technology orientation and innovation performance

	Innovation Performance	Availability of financial resources	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.000(0.032)	0.003(0.150)	0.000(0.031)
Firm Age	0.000(0.027)	-0.002(-0.129)	0.001(0.028)
Independent Variable			
Technology Orientation	0.382***(0.483)	0.291**(0.226)	0.380***(0.482)
Mediator			
Availability of financial resources			0.005(0.008)
R ²	0.239	0.097	0.239
Adjusted R ²	0.222	0.077	0.216
F Value	14.321	4.878	10.665

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardized regression coefficients (B) and standardized regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

This research further calculated the indirect mediation effect and total effect. As shown in Figure 6.2, the impact of technology orientation on innovation performance is exerted via two routes. The first is the direct effect of technology orientation on innovation performance (path c'). The second is the indirect effect (path ab=0.002, 0.226*0.008) through the availability of financial resources. The results show that the indirect mediation effect accounts for just 0.4% of the total mediation effect, which is the indirect effect divided by the total effect (0.002/0.483), suggesting the availability of financial resources does not significantly and partially mediate the relationship between the technology orientation and innovation performance, which does not support hypothesis 3. There are a few reasons for this result. This finding is consistent with some studies (Hoegl, Gibbert, and Mazursky, 2008; Keupp and Gassmann, 2013; Witell *et al.*, 2017). Internal financial resources could be vital for scientific research and innovation. However, as scientific research generates unexpected results, firms may undervalue this research activity (Aghion, David, and Foray, 2009). Thus, firms may only participate in scientific research and innovation when they have enough financial resources (Jissink, Schweitzer, and Rohrbeck, 2019). Similarly, if development is closer to the market, firms may participate in scientific research and innovation activities despite their financial position, as they may anticipate tangible gains on their investments (Czarnitzki, Hottenrott, and Thorwarth, 2011). The finding implies that the availability of financial resources does not necessarily affect tech-oriented SMEs' involvement in research and innovation activities to achieve innovation performance (Jane Hewerdine, Rummyantseva, and Welch, 2014).

Figure 6.2 The Mediating effect of the availability of financial resources between technology orientation and innovation performance



6.5.5 The mediating effect of networking capability between technology orientation and innovation performance

This study tested the mediating effects of the availability of networking capability between technology orientation and innovation performance. A mediating effect exists when the three conditions are satisfied (Baron and Kenny, 1986). Hypothesis 4 proposed that networking capability mediates the relationship between technology orientation and innovation performance. Table 6.4.3 provides the testing results of mediation for the networking capability via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is significantly associated with the dependent variable. The results show that technology orientation was significantly and positively related to innovation performance ($\beta=0.483$, $p<0.001$). In model 2, the independent variable, technology orientation, was regressed against the mediating variable, networking capability ($\beta=0.375$, $p<0.001$). Therefore, technology orientation was associated with networking capability, confirming the second condition. Model 3 tested whether the relationship between technology orientation and innovation performance

remained significant when the mediator, networking capability, was introduced into the initial relationship. The results showed that while the initial relationship between technology orientation and innovation performance continues to be significant ($\beta=0.320$, $p<0.001$), the effect of networking capability on innovation performance decreased when the mediator was introduced (β decreased from 0.483 to 0.320). The control variables' overall combined effect is small and insignificant on innovation performance ($R^2 =0.222$; $p\geq 0.05$).

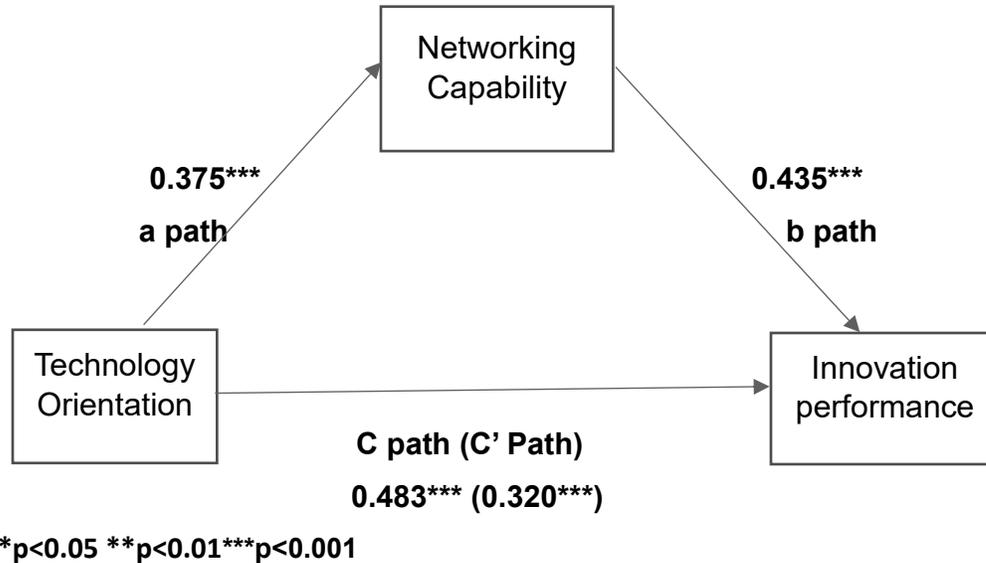
Table 6.4.3 Regression results for the mediating effect of networking capability on the relationship between the technology orientation and innovation performance

	Innovation Performance	Networking capability	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.000(0.032)	0.000(-0.027)	0.000(0.044)
Firm Age	0.000(0.027)	0.001(0.102)	-0.001(-0.017)
Independent Variable			
Technology Orientation	0.382***(0.483)	0.398***(0.375)	0.253***(0.320)
Mediator			
Networking Capability			0.324***(0.435)
R ²	0.239	0.156	0.398
Adjusted R ²	0.222	0.137	0.381
F Value	14.321	8.425	14.003

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardized regression coefficients (B) and standardized regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

This research further calculated the indirect mediation effect and total effect. As shown in Figure 6.3, the impact of technology orientation on innovation performance is exerted via two routes. The first is the direct effect of technology orientation on innovation performance (path c'). The second is the indirect effect (path ab=0.163, 0.375*0.435) through the networking capability. The results show that the indirect mediation effect accounts for 33.7% of the total mediation effect (0.163/0.483), suggesting networking capability partially and positively mediated the relationship between technology orientation and innovation performance, which supports hypothesis 4. This finding is consistent with previous studies (Huang *et al.*, 2012; Yang *et al.*, 2018). A high level of networking capability enables high-tech SMEs to actively learn new knowledge and skills from a network of actors and partners to accumulate necessary technologies, absorb them, and use them in the firm R&D activities to develop new products or services. The supposed rationale is that the quality of the relationships among employees and external partners acts as a facilitator and thus makes networking vital to these SMEs. The firm's readiness to partner in a trust-based manner enhances the absorptive capacity of new technologies (Cohen and Levinthal, 1990), the transfer of knowledge, the acquisition of tacit knowledge (Nonaka, 1994), the joint problem-solving and the coordination of complex tasks (Gulati and Singh, 1998), as well as the experimentation with different knowledge combinations (Cuevas-Rodríguez, Cabello-Medina, & Carmona-Lavado, 2014). All these factors enhance the efficiency of conversion of technology orientation to innovation performance.

Figure 6.3 The Mediating effect of networking capability between technology orientation and innovation performance



6.5.6 The mediating effect of the degree of openness between technology orientation and innovation performance

This study tested the mediating effects of the availability of the degree of openness between technology orientation and innovation performance. A mediating effect exists when the three conditions are satisfied (Baron and Kenny, 1986). First, the independent variable should be correlated with the dependent variable. Second, the independent variable and mediator are correlated. Third, as the mediating variable is added, the effect of the independent variable on the outcome variable must be significantly diminished or eliminated (Williams, Vandenberg, and Edwards, 2009). Hypothesis 5 proposed that the degree of openness mediates the relationship between technology orientation and innovation performance. Table 6.4.4 provides the testing results of mediation for the degree of openness via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is significantly associated with the dependent variable. The results show that technology orientation was significantly and positively related to innovation performance ($\beta=0.483$, $p<0.001$). In model 2, the

independent variable, technology orientation, was regressed against the mediating variable, degree of openness ($\beta=0.398$, $p<0.001$). Therefore, technology orientation was associated with networking capability, confirming the second condition. Model 3 tested whether the relationship between technology orientation and innovation performance remained significant when the mediator, degree of openness, was introduced into the initial relationship. The results showed that while the initial relationship between technology orientation and innovation performance continues to be significant ($\beta=0.344$, $p<0.001$), the effect of the degree of openness on innovation performance decreased when the mediator was introduced (β decreased from 0.483 to 0.344). The control variables' overall combined effect is small and insignificant on innovation performance ($R^2 =0.222$; $p\geq 0.05$).

Table 6.4.4 Regression results for the mediating effect of degree of openness on the relationship between the technology orientation and innovation performance

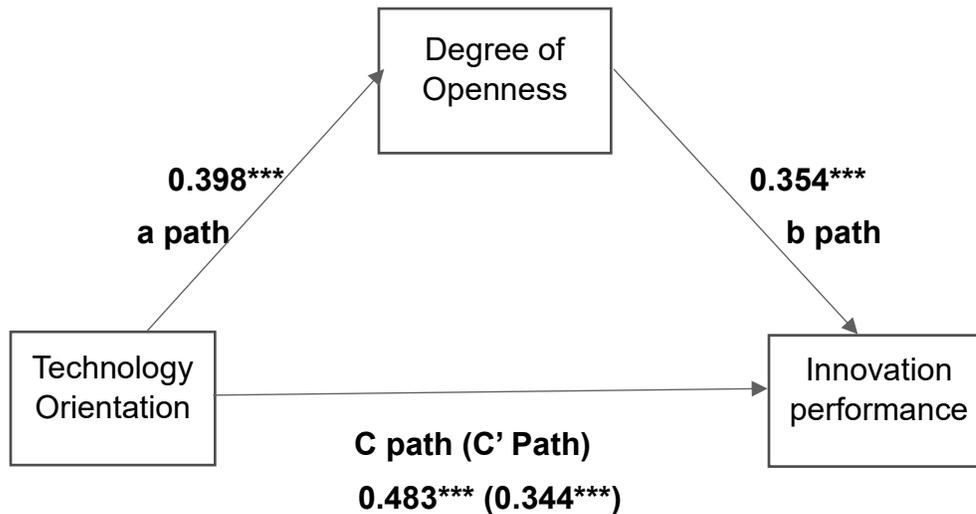
	Innovation Performance	Degree of Openness	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.000(0.032)	-0.002(-0.116)	0.000(0.044)
Firm Age	0.000(0.027)	-0.002(-0.117)	-0.001(-0.017)
Independent Variable			
Technology Orientation	0.382***(0.483)	0.508***(0.398)	0.272***(0.344)
Mediator			0.216***(0.354)
Degree of Openness			
R ²	0.239	0.156	0.398
Adjusted R2	0.222	0.137	0.381
F Value	14.321	8.425	14.003

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardized regression coefficients (B) and standardized regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

This research further calculated the indirect mediation effect and total effect. As shown in Figure 6.4, the impact of technology orientation on innovation performance is exerted via two routes. The first is the direct effect of technology orientation on innovation performance (path c'). The second is the indirect effect (path ab=0.141, 0.398×0.354) through the degree of openness. The results show that the indirect mediation effect accounts for 29.2% of the total mediation effect ($0.141/0.483$), suggesting the degree of openness partially and positively mediated the relationship between technology orientation and innovation performance, which supports hypothesis 5. This agrees with previous studies (Baum, Calabrese, & Silverman, 2000; Schilling and Phelps, 2007; Cuevas-Rodríguez, Cabello-Medina, & Carmona-Lavado, 2014). A firm's degree of openness enables high-tech firms to form technology alliances, which provide firms with access to external knowledge and skills, absorb them and transform them to enhance a firm's innovative performance in product development and new patent applications. In high-tech industries where innovation, technology, and time to market are critical factors for success, through openness, they can overcome their limited resources and any technological weaknesses they may have (Xiao and Ramsden, 2016).

Meanwhile, they must engage in some degree of openness to survive due to increased competition and a rapidly changing environment (Gulati, Nohria, and Zaheer, 2000; Gu, Zheng, and Liu, 2017). In that case, high-tech SMEs seek support from technology partners for knowledge and skills (Brunswick and Vanhaverbeke, 2015). Technology-oriented SMEs, through the degree of openness, can combine existing with new technological knowledge and achieve product innovations.

Figure 6.4 The Mediating Effect of Degree of Openness between Technology Orientation and Innovation Performance



* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

6.5.7 The mediating effect of structuring between the availability of technological resources and innovation performance

This study tested the mediating effects of the structuring of technological resources between the availability of technological resources and innovation performance. A mediating effect exists when the three conditions are satisfied (Baron and Kenny, 1986). First, the independent variable should be correlated with the dependent variable. Second, the independent variable and mediator are correlated. Third, as the mediating variable is added, the effect of the independent variable on the outcome variable must be significantly diminished or eliminated (Williams, Vandenberg, and Edwards, 2009). Hypothesis 6a proposed that structuring technological resources mediates the relationship between the availability of technological resources and innovation performance. Table 6.4.5 provides the testing results of mediation for structuring

technological resources via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is significantly associated with the dependent variable. The results show that the availability of technological resources was significantly and positively related to innovation performance ($\beta=0.416$, $p<0.001$). In model 2, the independent variable, availability of technological resources, was regressed against the mediating variable, structuring ($\beta=0.249$, $p<0.001$). Therefore, the availability of technological resources was associated with structuring, which confirmed the second condition. Model 3 tested whether the relationship between the availability of technological resources and innovation performance remained significant when the mediator, structuring, was introduced into the initial relationship. The results showed that while the initial relationship between the availability of technological resources and innovation performance continues to be significant ($\beta=0.249$, $p<0.001$), the availability of technological resources on innovation performance decreased when the mediator was introduced (β decreased from 0.416 to 0.249). The control variables' overall combined effect is small and insignificant on innovation performance ($R^2 =0.134$; $p\geq 0.05$).

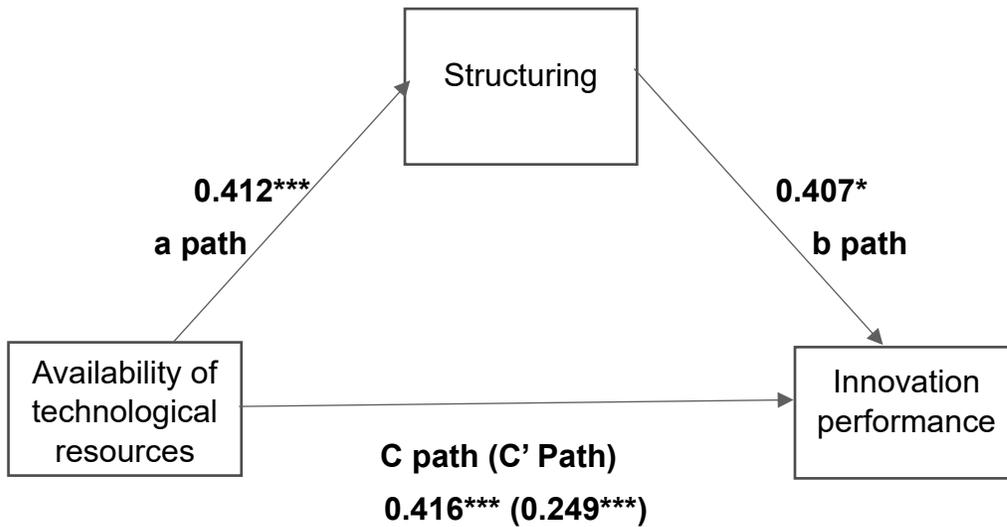
Table 6.4.5 Regression results for the mediating effect of structuring between availability of technological resources and innovation performance

	Innovation Performance	Structuring	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.001(0.053)	0.000(0.012)	0.000(0.028)
Firm Age	-0.000(-0.108)	-0.001(-0.059)	-0.001(-0.017)
Independent Variable			
Availability of Technology Resources	0.330***(0.416)	0.430***(0.412)	0.197***(0.249)
Mediator			
Structuring			0.310***(0.407)
R ²	0.153	0.156	0.292
Adjusted R2	0.134	0.138	0.271
F Value	8.229	8.451	14.003

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

This research further calculated the indirect mediation effect and total effect. As shown in Figure 6.5, the impact of the availability of technological resources on innovation performance is exerted via two routes. The first is the direct effect of the availability of technological resources on innovation performance (path c'). The second is the indirect effect (path ab) through structuring. The results show that the indirect mediation effect accounts for 40.3% of the total mediation effect ($0.412 \times 0.407 / 0.416$), suggesting structuring partially and positively mediated the relationship between the availability of technological resources and innovation performance, which supports hypothesis 6a. This finding is consistent with previous studies (Sedoglavich, 2012; Huang *et al.*, 2015). The availability of technological resources enables high-tech SMEs to learn new knowledge and skills actively, accumulate necessary technologies, absorb them, and use them in the firm R&D activities to develop new products or services. The finding implies that the availability of technological resources positively and significantly influences innovation performance through structuring. High-tech SMEs sometimes suffer from resource constraints and technological capabilities (Arzubiaga *et al.*, 2018). They must acquire and accumulate relevant resources and divest resources that are not needed to survive due to the accelerating change in the external environment and increasing competition (Sirmon *et al.*, 2011; Guo, Zheng, and Liu, 2017).

Figure 6.5 The Mediating effect of structuring between the availability of technological resources and innovation performance



*p<0.05 **p<0.01***p<0.001

6.5.8 The mediating effect of bundling between the availability of technological resources and innovation performance

This study tested the mediating effects of bundling between the availability of technological resources and innovation performance. A mediating effect exists when the three conditions are satisfied (Baron and Kenny, 1986). Hypothesis 6b proposed that the bundling of technological resources mediates the relationship between the availability of technological resources and innovation performance. Table 6.4.6 provides the testing results of mediation for the Bundling of technological resources via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is significantly associated with the dependent variable. The results show that the availability of technological resources was significantly and positively related to innovation performance ($\beta=0.416$, $p<0.01$). In model 2, the independent variable, the availability of

technological resources, was regressed against the mediating variable, the bundling of technological resources ($\beta=0.371$, $p<0.01$). Therefore, the availability of technological resources was associated with the bundling of technological resources, confirming the second condition. Model 3 tested whether the relationship between the availability of technological resources and innovation performance remained significant when the mediator, bundling, was introduced into the initial relationship. The results showed that both the availability of technological resources ($\beta=0.416$, $P<0.01$) and bundling ($\beta=0.371$, $P<0.01$) remained significant. The availability of technological resources on innovation performance decreased from 0.416 to 0.371 when the mediator was introduced (β ranged from 0.416 to 0.371). The results mean that bundling mediates the relationship between the availability of technological resources and innovation performance. Thus, hypothesis 6b is supported. The control variables' overall combined effect is small and insignificant on innovation performance ($R^2 = 0.134$; $p \geq 0.05$).

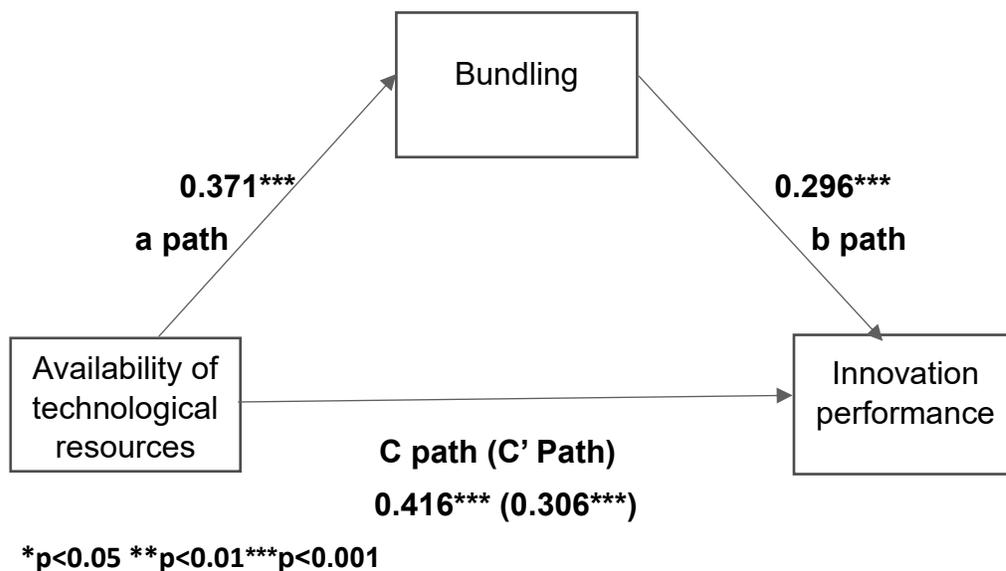
Table 6.4.6 Regression results for the mediating effect of bundling on the relationship between availability of technological resources and innovation performance

	Innovation Performance	Bundling	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.001(0.053)	0.001(0.064)	0.000(0.034)
Firm Age	-0.000(-0.108)	-0.001(-0.124)	-0.001(-0.071)
Independent Variable			
Availability of technological resources	0.330***(0.416)	0.349**(0.371)	0.243***(0.306)
Mediator			
Bundling			0.250***(0.296)
R ²	0.153	0.122	0.230
Adjusted R2	0.134	0.103	0.207
F Value	8.229	6.340	10.141

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

This research further calculated the indirect mediation effect and total effect. As shown in Figure 6.6, the impact of the availability of technological resources on innovation performance is exerted via two routes. The first is the direct effect of the availability of technological resources on innovation performance (path c'). The second is the indirect effect (path ab) through the bundling. The results show that the indirect mediation effect accounts for 26.3% of the total mediation effect ($0.371 \times 0.296 / 0.416$), suggesting bundling partially and positively mediated the relationship between the availability of technological resources and innovation performance, which supports hypothesis 6b. This finding is consistent with previous studies (Srivardhana and Pawlowski, 2007; Carnes, 2016). For instance, Srivardhana and Pawlowski, 2007) argued that an enterprise resource planning system as a technological resource can enable business process innovation when strategically bundled into a technological capability.

Figure 6.6 The Mediating effect of bundling between the availability of technological resources and innovation performance



6.5.9 The mediating effect of leveraging between the availability of technological resources and innovation performance

This study tested the mediating effects of leveraging between the availability of technological resources and innovation performance. Hypothesis 6c proposed that leveraging mediates the relationship between the availability of technological resources and innovation performance. Table 6.4.7 provides the testing results of mediation for leveraging technological resources via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is significantly associated with the dependent variable. The results show that the availability of technological resources was significantly and positively related to innovation performance ($\beta=0.416$, $p<0.01$). In model 2, the independent variable, the availability of technological resources, was regressed against the mediating variable, leveraging ($\beta=0.496$, $p<0.01$). Therefore, the availability of technological resources was associated with leveraging, which confirmed the second condition. Model 3 tested whether the relationship between the availability of technological resources and innovation performance remained significant when the mediator, the leveraging, was introduced into the initial relationship. The results showed that both the availability of technological resources ($\beta=0.212$, $P<0.01$) and leveraging ($\beta=0.412$, $P<0.01$) remained significant. However, the coefficients of the effect of availability of technological resources on innovation performance decreased from 0.416 to 0.212. It indicated that the significance of the relationship between the availability of technological resources and innovation performance reduced after leveraging was added to the analysis, which means that leveraging mediated the relationship between the availability of technological resources and innovation performance. Thus, hypothesis 6c is supported. The control variables' overall combined effect is small and insignificant on innovation performance ($R^2 = 0.134$; $p \geq 0.05$).

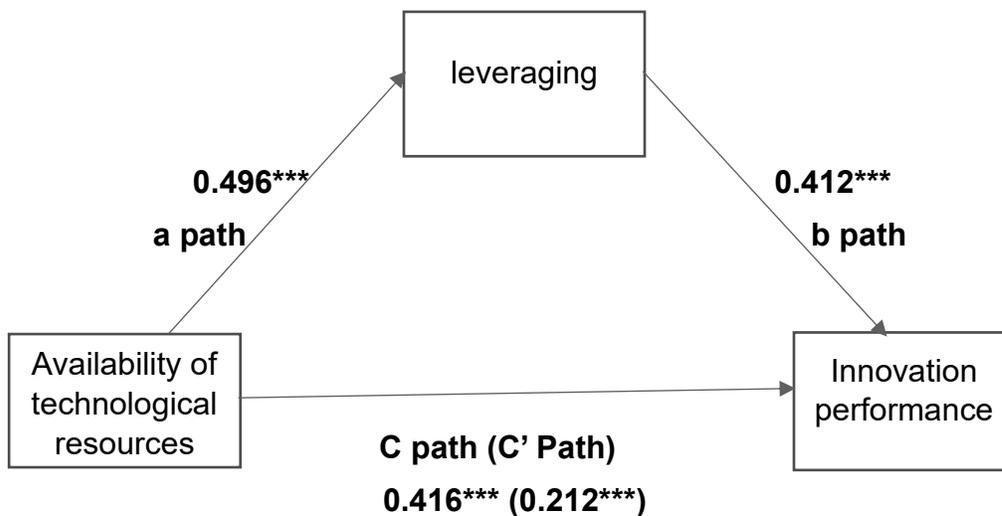
Table 6.4.7 Regression results for the mediating effect of leveraging on the relationship between the availability of technological resources and innovation performance

	Innovation Performance	Leveraging	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.001(0.053)	0.000(0.022)	0.000(0.034)
Firm Age	-0.000(-0.108)	0.000(-0.042)	-0.001(-0.071)
Independent Variable			
Availability of technological resources	0.330***(0.416)	0.467***(0.496)	0.168***(0.212)
Mediator			
Leveraging			0.346***(0.412)
R ²	0.153	0.215	0.230
Adjusted R2	0.134	0.198	0.207
F Value	8.229	12.542	10.141

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

This research further calculated the indirect mediation effect and total effect. As shown in Figure 6.7, the impact of the availability of technological resources on innovation performance is exerted via two routes. The first is the direct effect of the availability of technological resources on innovation performance (path c'). The second is the indirect effect (path ab) through the leveraging. The results show that the indirect mediation effect accounts for 49.1% of the total mediation effect ($0.496 \times 0.412 / 0.416$), suggesting leveraging partially and positively mediated the relationship between the availability of technological resources and innovation performance, which supports hypothesis 6c. This finding is consistent with previous studies (Crick and Spence, 2005; Xu and Muneyoshi, 2016). The high availability of technological resources and capabilities enables high-tech SMEs to learn new knowledge and skills actively, accumulate necessary technologies, absorb them, and enrich them into technological and R&D capabilities that can be used to develop superior products and services. These capabilities are leveraged by building a system or process and automating a process with technology, and these are deployed in the marketplace for innovation performance. The finding implies that the availability of technological resources positively affected innovation performance through leveraging.

Figure 6.7 The Mediating effect of leveraging between the availability of technological resources and innovation performance.



*p<0.05 **p<0.01***p<0.001

6.6 The mediating effects of structuring between the availability of financial resources and innovation performance

This study tested the mediating effects of the structuring between the availability of financial resources and innovation performance. A mediating effect exists when the three conditions are satisfied (Baron and Kenny, 1986). First, the independent variable should be correlated with the dependent variable. Second, the independent variable and mediator are correlated. Third, as the mediating variable is added, the effect of the independent variable on the outcome variable must be significantly diminished or eliminated (Williams, Vandenberg, and Edwards, 2009). Hypothesis 7a proposed that structuring mediates the relationship between the availability of financial resources and innovation performance. Table 6.4.8 provides the testing results of mediation for structuring via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is significantly associated with the dependent variable. The results show that the availability of financial resources was not significantly related to innovation performance ($\beta=0.121$, $p>0.05$). In model 2, the independent variable, availability of financial resources, was regressed against the mediating variable, structuring. The results show that the availability of financial resources was not significantly related to structuring ($\beta=-0.496$, $p>0.05$). Therefore, the availability of financial resources was not correlated with the structuring, which violated the second condition. Model 3 tested whether the relationship between the availability of financial resources and innovation performance remained significant when the mediator, the structuring, was introduced into the initial relationship. The results showed that both the availability of financial resources ($\beta=0.167$, $P<0.05$) and the structuring ($\beta=0.509$, $P<0.01$) remained significant.

However, the coefficients of the effect of availability of financial resources on innovation performance increased from 0.121 to 0.167. It indicated that the significance of the relationship between the availability of financial resources and innovation performance was not reduced when the mediator was added to the analysis, which means that structuring is not mediating the relationship between the availability of financial resources

and innovation performance. The control variables' overall combined effect is insignificant on innovation performance ($R^2 = 0.00$; $p \geq 0.05$).

Table 6.4.8 Regression results for the mediating effect of structuring on the relationship between the availability of financial resources and innovation performance

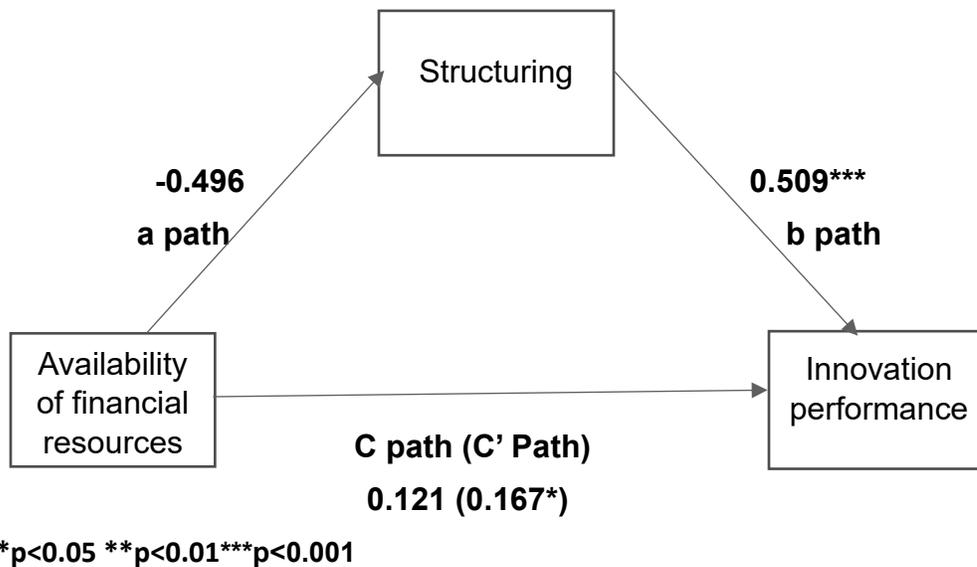
	Innovation Performance	Structuring	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.001(0.048)	0.002(0.129)	0.000(-0.018)
Firm Age	0.001(0.073)	0.000(0.036)	0.000(0.055)
Independent Variable			
Availability of financial resources	0.074(0.121)	-0.073(-0.496)	0.102*(0.167)
Mediator			
Structuring			0.387***(0.509)
R ²	0.021	0.022	0.230
Adjusted R2	0.000	0.000	0.207
F Value	0.984	1.007	10.141

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

As shown in Figure 6.8, structuring does not mediate the relationship between the availability of financial resources and innovation performance, which does not support hypothesis 7a. Hypothesis 7a proposed that structuring mediates this relationship. However, the results shown in this sample do not support this hypothesis.

Moreover, Figure 6.8 also shows that the direct effect (path $c' = 0.167$, $c = 0.121$) and indirect effect (path $ab = -0.496$, -0.496×0.509) of the availability of financial resources on innovation performance are not significant. The results show that the indirect mediation effect accounts for -208.6% of the total mediation effect ($-0.046/0.121$), which further confirmed that structuring does not mediate the relationship between the availability of financial resources and innovation performance, which does not support hypothesis 7a.

Figure 6.8 The Mediating effect of structuring between the availability of financial resources and innovation performance



6.6.1 The mediating effect of bundling between availability of financial resources and innovation performance

This study tested the mediating effect of bundling between the availability of financial resources and innovation performance. Hypothesis 7b proposed that the bundling of resources mediates the relationship between the availability of financial resources and innovation performance. Table 6.4.9 provides the testing results of mediation for bundling of resources via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is not associated with the dependent variable. The results show that the availability of financial resources was not significantly correlated to innovation performance ($\beta=0.121$, $p>0.05$). In model 2, the independent variable, technology orientation, was regressed against the mediating variable, bundling of resources ($\beta=0.355$, $p<0.001$). Therefore, the availability of financial resources was associated with the bundling, which confirmed the second condition. Model 3 tested whether the relationship between the availability of financial resources and innovation performance remained significant when the mediator, bundling, was introduced into the initial relationship. The results showed that the relationship between availability of financial resources and innovation performance is not significant ($\beta=-0.021$, $p>0.05$), even though the effect of availability of financial resources on innovation performance decreased when the mediator was introduced (β ranged from 0.121 to -0.021). This result shows that bundling fully mediates the relationship between the availability of financial resources and innovation performance.

Moreover, Figure 6.9 also shows that the direct effect (path $c'=-0.021$, $c=0.121$) and indirect effect (path $ab=0.142$, $0.355*0.400$) of the availability of financial resources on innovation performance are significant. The results show that the indirect mediation effect accounts for 117.4% of the total mediation effect ($ab/c=0.142/0.121$), further confirming that bundling mediates the relationship between availability of financial resources and innovation performance. The control variable's overall combined effect is also insignificant on innovation performance ($R^2=0.00$; $p\geq 0.05$).

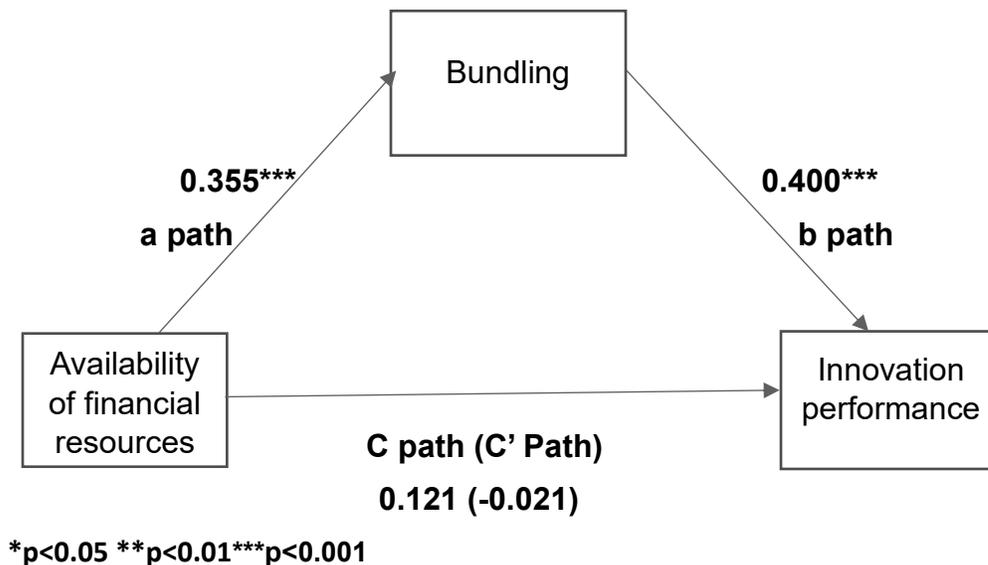
Table 6.4.9 Regression results for the mediating effect of bundling on the relationship between availability of financial resources and innovation performance

	Innovation Performance	Bundling	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.001(0.048)	0.000(0.019)	0.000(0.041)
Firm Age	0.001(0.073)	0.001(0.066)	0.000(0.047)
Independent Variable			
Availability of financial resources	0.074(0.121)	0.259*** (0.355)	-0.013(-0.021)
Mediator			
Bundling			0.337*** (0.400)
R ²	0.021	0.127	0.230
Adjusted R2	0.000	0.108	0.207
F Value	0.984	6.631	10.141

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

As shown in Figure 6.9, Bundling fully mediates the relationship between the availability of financial resources and innovation performance, which supports hypothesis 7b. Hypothesis 7b proposed that bundling mediates the relationship between the availability of financial resources and innovation performance. Therefore, the hypothesis is supported.

Figure 6.9 The Mediating effect of the bundling of financial resources



6.6.2 The mediating effect of leveraging between the availability of financial resources and innovation performance

This study tested the mediating effect of the leveraging between the availability of financial resources and innovation performance. Hypothesis 7c proposed that leveraging mediates the relationship between the availability of financial resources and innovation performance. Table 6.5 provides the testing results of the mediation of leveraging financial resources via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is significantly associated with the dependent variable. The results show that the availability of financial resources was insignificant and does not correlate to innovation performance ($\beta=0.121$, $p>0.05$). In

model 2, the independent variable, the availability of financial resources, was regressed against the mediating variable, leveraging ($\beta=0.298$, $p<0.01$). Therefore, the availability of financial resources was associated with leveraging, confirming the second condition. Model 3 tested whether the relationship between the availability of financial resources and innovation performance was significant when the mediator leveraging was introduced into the initial relationship. The results showed that the initial relationship between the availability of financial resources and innovation performance is not significant ($\beta=-0.031$, $p>0.05$), even though the effect of availability of financial resources on innovation performance decreased when the mediator was introduced (β ranged from 0.121 to -0.031). This result shows that leveraging fully mediates the relationship between the availability of financial resources and innovation performance. The control variables' overall combined effect is insignificant on innovation performance ($R^2 = 0.00$; $p \geq 0.05$).

Table 6.5 Regression results for the mediating effect of leveraging on the relationship between availability of financial resources and innovation performance

	Innovation Performance	Leveraging	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.001(0.048)	0.001(0.043)	0.000(0.027)
Firm Age	0.001(0.073)	0.001(0.074)	0.000(0.036)
Independent Variable			
Availability of financial resources	0.074(0.121)	0.217*** (0.298)	0.019(0.031)
Mediator			
leveraging			0.429*** (0.510)
R ²	0.021	0.094	0.230
Adjusted R ²	0.000	0.074	0.207
F Value	0.984	4.728	10.141

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

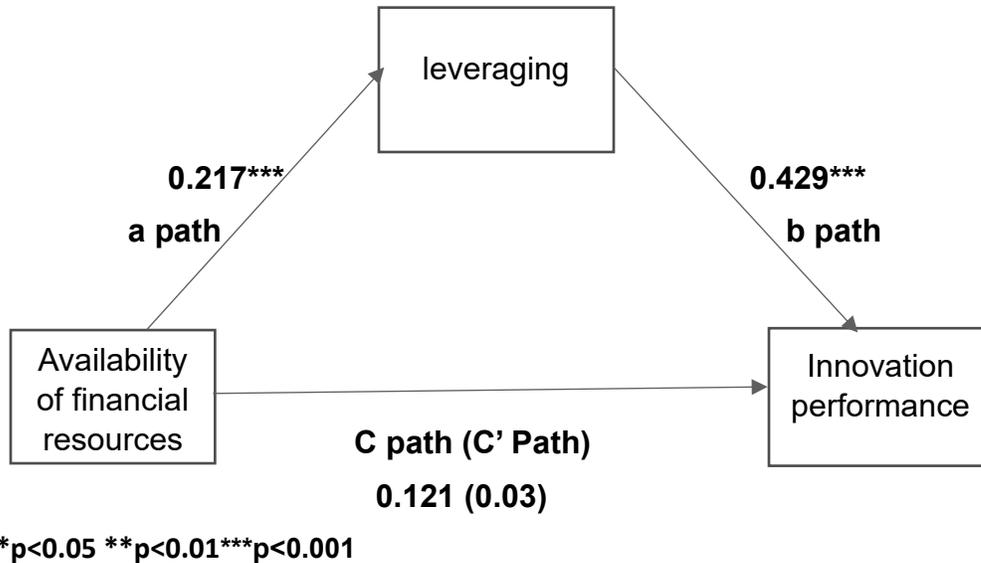
This research further calculated the indirect mediation effect and total effect. As shown in Figure 6.9.1, the impact of the availability of financial resources on innovation performance is exerted via two routes. The first is the direct effect of the availability of financial resources on innovation performance (path c'). The second is the indirect effect (path ab) through the leveraging. The results show that the indirect mediation effect accounts for 76.9% of the total mediation effect ($0.217 \times 0.429 / 0.121$), suggesting leveraging fully and positively mediated the relationship between the availability of financial resources and innovation performance, which supports hypothesis 7c. The argument for hypotheses 7a, 7b and 7c assumes that the structuring, bundling, and leveraging positively mediate the technology orientation and innovation performance relationship. However, hypothesis 7a is not supported, while only bundling and leveraging support hypotheses 7b and 7c. According to Berends *et al.* (2014), Bicen and Johnson (2014) and De Massis *et al.* (2018) demonstrated that some firms, especially small-sized firms, can still engage in technology research and innovation despite having limited financial resources. Also, Berends *et al.* (2014) highlight that small-sized firms' research and innovation activities are typically informal, opportunistic, and more dependent on external knowledge and spillovers rather than internal R&D investments such as internal financial resources. The competitive advantage of small-sized firms mainly resides in their behavioural resources rather than their bundles of capital and financial resources (Freel, 2000). The flexibility of decision-making, for instance, is a crucial behavioural advantage to refocus organisational objectives and routines when markets change (Berends *et al.*, 2014).

Gibbert and Scranton (2009) and Keupp and Gassmann (2013) also showed that financial resource constraints could encourage firm-level research and innovation. For example, an in-depth comparative study of a particular innovation in jet propulsion technology shows that leveraging new knowledge in the organisation fostered innovation even with financial resource constraints where just the availability of resources in a comparable situation did not (Gibbert and Scranton, 2009). In addition, there is also related research at the organisational and the individual level suggesting that budget constraints may facilitate, rather than inhibit, innovation. For instance, Katila and Shane (2005) analyse the influence of resource scarcity on innovation performance at the organisational level,

comparing new firms (with fewer resources) and established firms (with more significant resources) and specify environmental conditions under which new firms may show a higher (not just equal) rate of innovation than established ones.

Furthermore, it was shown that thinking 'inside the box' enhances the creation of new ideas. Teams with a creative approach towards bounded methods will find innovating easier and more natural even with financial constraints. A fundamental assumption in work on creative cognition in the field of psychology is that the human mind is most creative when given less, instead of more, alternatives to solve an innovation problem (e.g., Finke, 1990; Kelly *et al.*, 1990; Finke *et al.*, 1992; Ward, 1994; Durham *et al.*, 2000). A bounded creativity approach is more appropriate because it believes less is better. Thus, when financial resources are limited, applying bounded creativity methods will prove helpful in facilitating innovation activities through leveraging domain-relevant knowledge and skills. Intensive collaboration allows teams to identify and share domain-relevant skills (Madhavan and Grover, 1998). There is synergistic potential among the various interdependent parts of a project (Hitt *et al.*, 1993). As documented in previous research (Easley *et al.*, 2003; Hoegl and Gemuenden, 2001), teams with such high-quality teamwork openly communicate relevant information (Hauptman and Hirji, 1996), coordinate their activities (Adler, 1995; Faraj and Sproull, 2000), and therefore make sure that all team members can contribute their knowledge to their full potential (Seers, 1989), which, in turn, supports innovation team performance under financial scarcity.

Figure 6.9.1 The Mediating effect of leveraging between the availability of financial resources and innovation performance



6.6.3 The mediating effect of structuring between networking capability and innovation performance

This study tested the mediating effect of structuring between networking capability and innovation performance. A mediating effect exists when the three conditions are satisfied (Baron and Kenny, 1986). First, the independent variable should be correlated with the dependent variable. Second, the independent variable and mediator are correlated. Third, as the mediating variable is added, the effect of the independent variable on the outcome variable must be significantly diminished or eliminated (Williams, Vandenberg, and Edwards, 2009). Hypothesis 8a proposed that structuring mediates the relationship between networking capability and innovation performance. Table 6.5.1 provides the testing results of mediation for structuring via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is correlated with the dependent variable. The results show that networking capability was significantly correlated to innovation performance ($\beta=0.556$, $p<0.05$). In model 2, the independent variable, networking capability, was regressed against the mediating variable, structuring

($\beta=0.522$, $p<0.001$). Therefore, networking capability was correlated with structuring, which confirmed the second condition. Model 3 tested whether the relationship between networking capability and innovation performance remained significant when the mediator, structuring, was introduced into the initial relationship. The results showed a significant relationship between network capability and innovation performance ($\beta=0.409$, $p<0.001$). As the mediating variable was added, the effect of the independent variable on the dependent variable was decreased from ($\beta=0.556$ to 0.409). The result means that structuring positively and partially mediates the relationship between networking capability and innovation performance. The control variables' overall combined effect is small and insignificant on innovation performance ($R^2 = 0.296$; $p \geq 0.05$).

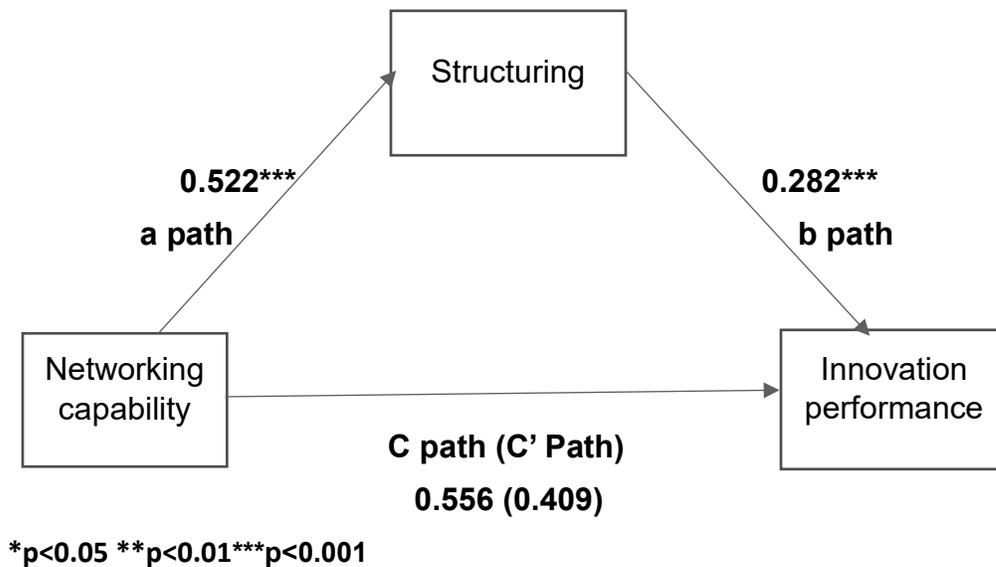
Table 6.5.1 Regression results for the mediating effect of structuring on the relationship between networking capability and innovation performance

	Innovation Performance	Structuring	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.001(0.068)	0.000(0.019)	0.000(0.041)
Firm Age	-0.001(-0.011)	0.001(0.066)	0.000(0.047)
Independent Variable			
Networking capability	0.414***(0.556)	0.511***(0.522)	0.305***(0.409)
Mediator			
Structuring			0.214***(0.282)
R ²	0.311	0.282	0.368
Adjusted R2	0.296	0.266	0.350
F Value	0.984	17.905	19.818

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

Moreover, Figure 6.9.2 also shows that the direct effect (path $c'=0.409$) and indirect effect (path $ab=0.147$, 0.522×0.282) of networking capability on innovation performance are significant. The results show that the indirect mediation effect accounts for 26.5% of the total mediation effect ($0.147/0.556$), further confirming that structuring positively and partially mediates the relationship between networking capability and innovation performance. The results shown in this sample do support this hypothesis 8a.

Figure 6.9.2 The Mediating effect of structuring between networking capability and innovation performance



6.6.4 The mediating effect of bundling between networking capability and innovation performance

This study tested the mediating effect of bundling between networking capability and innovation performance. Hypothesis 8b proposed that bundling of networking capability mediates the relationship between networking capability and innovation performance. Table 6.5.2 provides the testing results of mediation for bundling via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is correlated with the dependent variable. The results show that networking

capability was significantly correlated to innovation performance ($\beta=0.414$, $p<0.001$). In model 2, the independent variable, networking capability, was regressed against the mediating variable, bundling ($\beta=0.450$, $p<0.001$). Therefore, networking capability was correlated with the bundling, which confirmed the second condition. Model 3 tested whether the relationship between networking capability and innovation performance remained significant when the mediator, bundling, was introduced into the initial relationship. The results showed a significant relationship between networking capability and innovation performance ($\beta=0.475$, $p<0.001$). However, the coefficients of the effect of networking capability on innovation performance decreased from 0.556 to 0.475. It indicated that the significance of the relationship between networking capability and innovation performance reduced after bundling was added to the analysis, which means that bundling positively and partially mediates the relationship between networking capability and innovation performance. The control variables' overall combined effect is small and insignificant on innovation performance ($R^2 = 0.188$; $p \geq 0.05$).

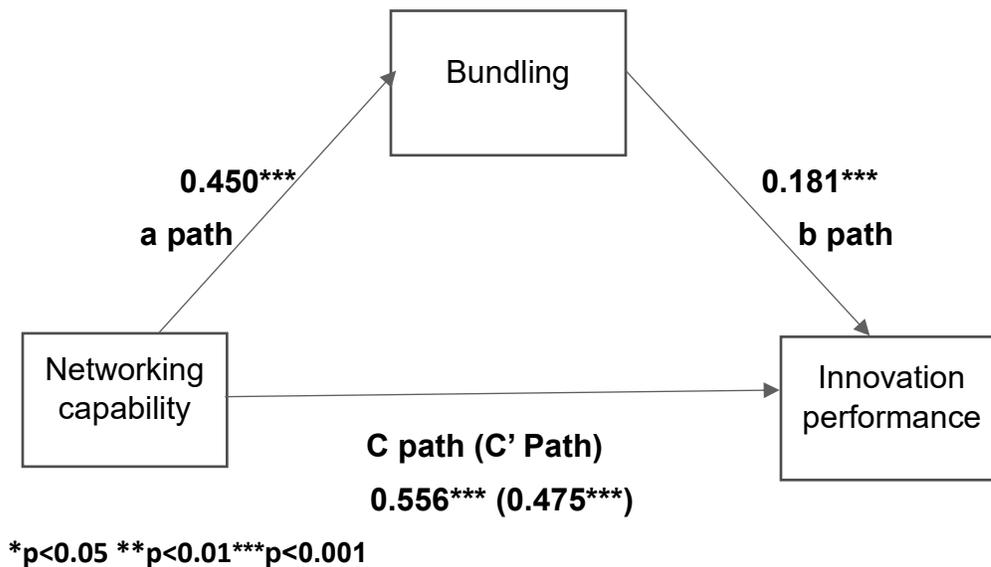
Table 6.5.2 Regression results for the mediating effect of bundling on the relationship between networking capability and innovation performance

	Innovation Performance	Bundling	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.000(0.032)	0.000(0.011)	0.000(0.041)
Firm Age	0.001(0.078)	0.001(0.068)	0.000(0.047)
Independent Variable			
Networking capability	0.414***(0.556)	0.397***(0.450)	0.354***(0.475)
Mediator			
Bundling of networking capability			0.153***(0.181)
R ²	0.205	0.311	0.368
Adjusted R2	0.188	0.296	0.350
F Value	11.803	20.639	19.818

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

Moreover, Figure 6.9.3 also shows that the direct effect (path $c'=0.354$) and indirect effect (path $ab=0.081$, 0.450×0.181) of bundling on innovation performance are significant. The results show that the indirect mediation effect accounts for 14.6% of the total mediation effect ($0.081/0.556$), further confirming that bundling positively and partially mediates the relationship between networking capability and innovation performance. The results shown in this sample support hypothesis 8b.

Figure 6.9.3 The Mediating effect of the bundling of networking capability



6.6.5 The mediating effect of leveraging between networking capability and innovation performance

This study tested the mediating effect of leveraging between networking capability and innovation performance. Hypothesis 8c proposed that leveraging networking capability mediates the relationship between networking capability and innovation performance. Table 6.5.3 provides the testing results of mediation for leveraging via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is correlated with the dependent variable. The results show that networking capability was significantly correlated to innovation performance ($\beta=0.556$, $p < 0.001$). In

model 2, the independent variable, networking capability, was regressed against the mediating variable, leveraging ($\beta=0.450$, $p<0.001$). Therefore, networking capability was correlated with leveraging, which confirmed the second condition. Model 3 tested whether the relationship between networking capability and innovation performance remained significant when the mediator leveraging was introduced into the initial relationship. The results showed a significant relationship between networking capability and innovation performance ($\beta=0.399$, $p<0.001$). However, the coefficients of the effect of networking capability on innovation performance decreased from 0.556 to 0.399. The result indicated that the significance of the relationship between networking capability and innovation performance reduced after leveraging was added to the analysis, which means that leveraging positively and partially mediates the relationship between networking capability and innovation performance. Furthermore, the control variables' overall combined effect is small and insignificant on innovation performance ($R^2 = 0.188$; $p \geq 0.05$).

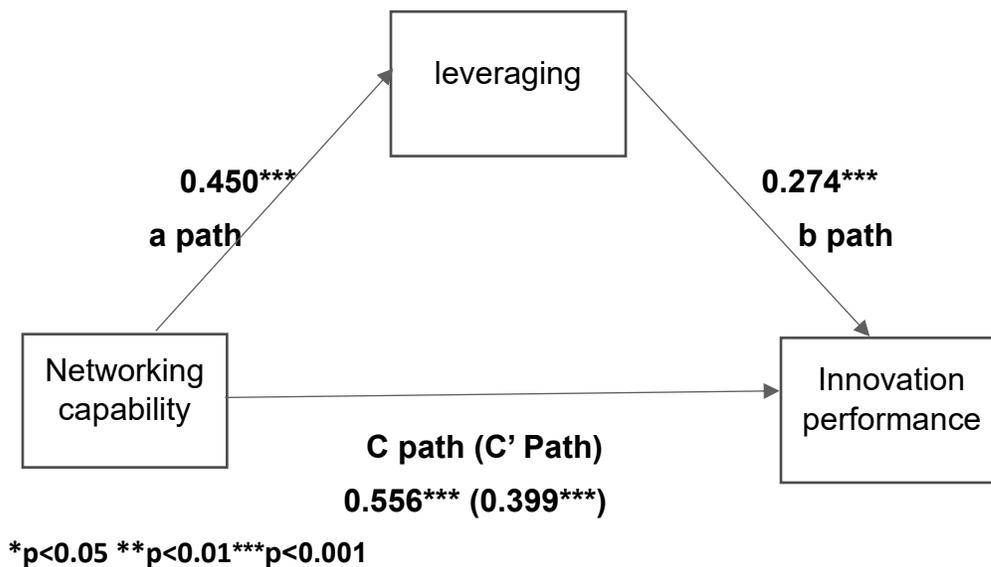
Table 6.5.3 Regression results for the mediating effect of leveraging on the relationship between networking capability and innovation performance

	Innovation Performance	Leveraging	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.000(0.032)	0.000(0.011)	0.000(0.041)
Firm Age	0.001(0.078)	0.001(0.068)	0.000(0.047)
Independent Variable			
<i>Networking capability</i>	0.414***(0.556)	0.397***(0.450)	0.298***(0.399)
Mediator			
leveraging of networking capability			0.231***(0.274)
R ²	0.205	0.362	0.362
Adjusted R2	0.188	0.343	0.343
F Value	11.803	19.268	19.818

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

Hypothesis 8c proposed that leveraging mediates the relationship between networking capability and innovation performance. The results shown do support this hypothesis. Moreover, figure 6.9.4 also shows that the direct effect (path c'=0.399) and indirect effect (path ab=0.123, 0.450×0.274) of leveraging on innovation performance are significant. The results show that the indirect mediation effect accounts for 22.2% of the total mediation effect ($0.123/0.556$), further confirming that leveraging positively and partially mediates the relationship between networking capability and innovation performance. The results shown in this sample support hypothesis 8c.

Figure 6.9.4 The Mediating effect of leveraging between networking capability and Innovation performance.



The argument for hypotheses 8a, 8b and 8c argues that the structuring, bundling, and leveraging positively mediate the technology orientation and innovation performance relationship; the result shows that the hypothesis is supported. This finding is consistent with previous studies that say small firms often exploit external networks as a principal source of innovation since small firms frequently lack the internal resources available to large firms, and interactions with and using resources from these networks can accelerate the speed of innovation and reduce uncertainty in new product development (Bierly, Lii

and Daly, 2007). Therefore, the innovation performance of high-tech SMEs is improved. For example, in a longitudinal study of Spanish manufacturing firms, Nieto and Santamaría (2007) found that firms benefit most from innovation novelty from collaboration networks comprising different partners. Additionally, Gu, Jiang and Wang (2016), in a sample of Chinese high-tech small and medium-sized enterprises (SMEs), found that cooperative networks have positive effects on the innovation performance of high-tech SMEs such that new forms of knowledge and the resources and technology adopted from these networks are used to strengthen the internal R&D intensity which results in more new product development and in innovation performance in the high-tech SMEs (Leitner, 2011).

6.6.6 The mediating effect of structuring between the degree of openness and innovation performance

This study tested the mediating effect of structuring between the degree of openness and innovation performance. A mediating effect exists when the three conditions are satisfied (Baron and Kenny, 1986). First, the independent variable should be correlated with the dependent variable. Second, the independent variable and mediator are correlated. Third, as the mediating variable is added, the effect of the independent variable on the outcome variable must be significantly diminished or eliminated (Williams, Vandenberg, and Edwards, 2009). Hypothesis 9a proposed that structuring mediates the relationship between the degree of openness and innovation performance. Table 6.5.4 provides the testing results of mediation for structuring via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is correlated with the dependent variable. The results show that the degree of openness was significantly correlated to innovation performance ($\beta=0.556$, $p<0.001$). In model 2, the independent variable, the degree of openness, was regressed against the mediating variable, structuring ($\beta=0.377$, $p<0.001$). Therefore, the degree of openness was correlated with structuring, which confirmed the second condition. Model 3 tested whether the relationship between the degree of openness and innovation performance remained significant when the mediator, structuring, was introduced into the initial relationship. The results showed that both the degree of openness ($\beta=0.556$, $p<0.001$) and innovation

performance ($\beta=0.354$, $p<0.001$) remained significant. However, the coefficients of the degree of openness on innovation performance decreased from 0.556 to 0.354. The result indicated that the significance of the relationship between the degree of openness and innovation performance was reduced after structuring was added to the analysis, which implies that structuring partially mediates the relationship between the degree of openness and innovation performance. Furthermore, the control variables' overall combined effect is small and insignificant on innovation performance ($R^2 = 0.227$; $p \geq 0.05$).

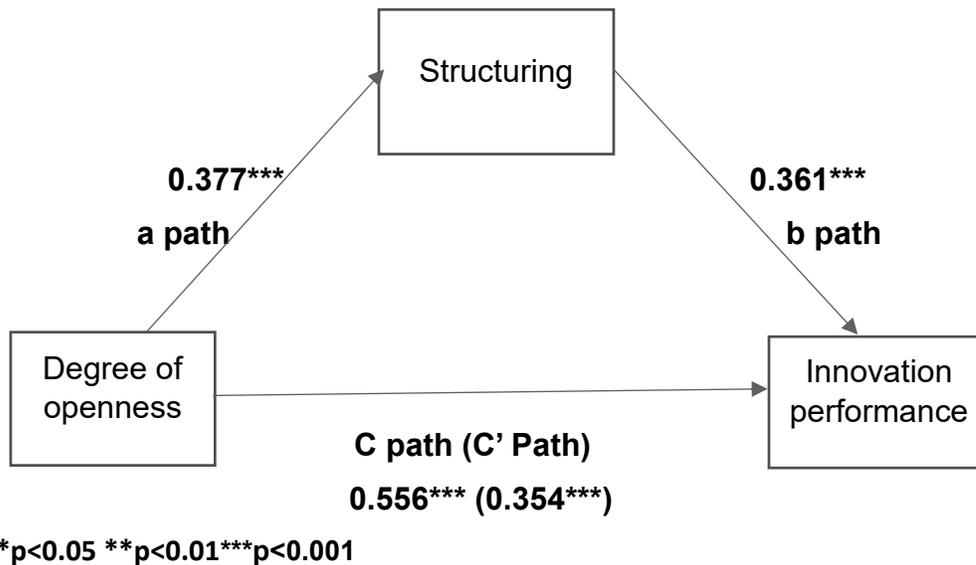
Table 6.5.4 Regression results for the mediating effect of structuring on the relationship between degree of openness and innovation performance

	Innovation Performance	Structuring	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.001(0.111)	0.002(0.147)	0.001(0.058)
Firm Age	0.001(0.104)	0.001(0.081)	0.001(0.075)
Independent Variable			
Degree of openness	0.300***(0.556)	0.303***(0.377)	0.216***(0.354)
Mediator			
Structuring			0.275***(0.361)
R ²	0.244	0.154	0.354
Adjusted R ²	0.227	0.135	0.335
F Value	14.716	8.295	18.648

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

This research further calculated the indirect mediation effect and total effect. As shown in Figure 6.9.5, the impact of structuring on innovation performance is exerted via two routes. The first is the direct effect of structuring on innovation performance (path c'). The second is the indirect effect (path ab=0.136, 0.377*0.361) through structuring. The results show that the indirect mediation effect accounts for 24.5% of the total mediation effect (0.136/0.556), suggesting that partially and positively structuring mediates the relationship between the degree of openness and innovation performance, which supports hypothesis 9a.

Figure 6.9.5 The Mediating effect of structuring between the degree of openness and innovation performance



6.6.7 The mediating effect of bundling between degree of openness and innovation performance

This study tested the mediating effect of bundling between the degree of openness and innovation performance. Hypothesis 9b proposed that bundling mediates the relationship between the degree of openness and innovation performance. Table 6.5.5 provides the testing results of mediation for bundling via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is correlated with the

dependent variable. The results show that the degree of openness was significantly correlated to innovation performance ($\beta=0.556$, $p<0.001$). In model 2, the independent variable, the degree of openness, was regressed against the mediating variable, bundling ($\beta=0.450$, $p<0.001$). Therefore, the degree of openness was correlated with bundling, which confirmed the second condition. Model 3 tested whether the relationship between the degree of openness and innovation performance remained significant when the mediator, bundling, was introduced into the initial relationship. The results showed that both the degree of openness ($\beta=0.556$, $p<0.001$) and innovation performance ($\beta=0.408$, $p<0.001$) remained significant. However, the coefficients of the degree of openness on innovation performance decreased from 0.556 to 0.408. It indicated that the significance of the relationship between the degree of openness and innovation performance was reduced after bundling was added to the analysis, which implies that bundling partially mediates the relationship between the degree of openness and innovation performance. Furthermore, the control variables' overall combined effect is small and insignificant on innovation performance ($R^2 = 0.227$; $p \geq 0.05$). Furthermore, the control variables' overall combined effect is small and insignificant on innovation performance ($R^2 = 0.227$; $p \geq 0.05$).

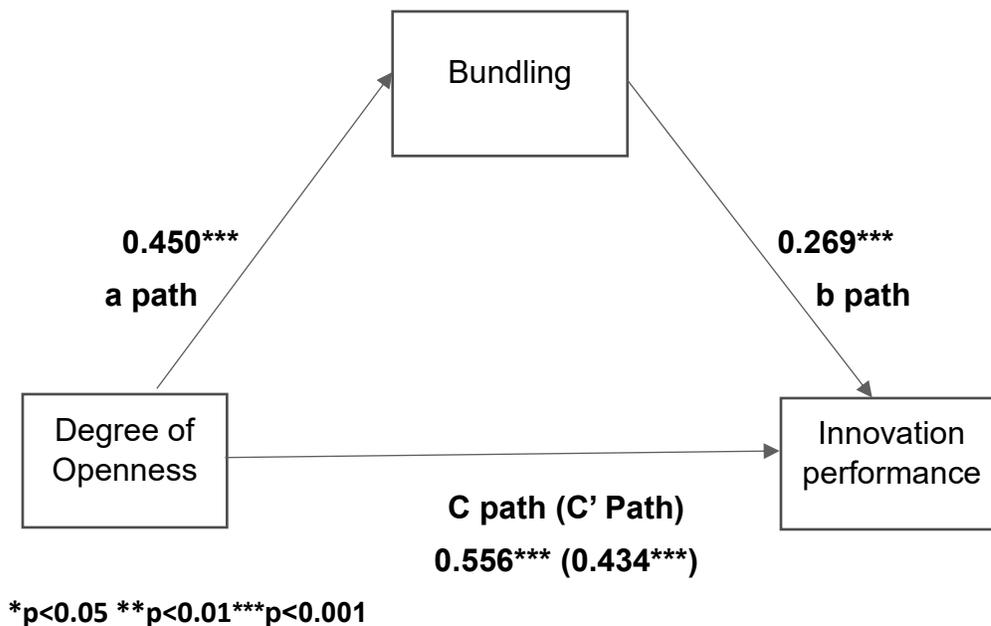
Table 6.5.5 Regression results for the mediating effect of bundling on the relationship between degree of openness and innovation performance

	Innovation Performance	Bundling	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.000(0.032)	0.000(0.011)	0.000(0.083)
Firm Age	0.001(0.078)	0.001(0.068)	0.000(0.090)
Independent Variable			
Degree of openness	0.414***(0.556)	0.397***(0.450)	0.250***(0.408)
Mediator			
Bundling			0.227***(0.269)
R ²	0.244	0.311	0.309
Adjusted R2	0.227	0.296	0.289
F Value	14.716	20.639	15.214

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation; ^aNatural Logarithm of the number of full-time employees.

This research further calculated the indirect mediation effect and total effect. As shown in Figure 6.9.6, the impact of bundling on innovation performance is exerted via two routes. The first is the direct effect of the degree of openness on innovation performance (path c'). The second is the indirect effect (path ab=0.121, 0.450×0.269) through bundling. The results show that the indirect mediation effect accounts for 21.8% of the total mediation effect ($0.121/0.556$), suggesting bundling partially and positively mediates the relationship between the degree of openness and innovation performance, which supports hypothesis 9b.

Figure 6.9.6 The Mediating effect of bundling between the degree of openness and innovation performance



6.6.8 The mediating effects of leveraging between degree of openness and innovation performance

This study tested the mediating effect of leveraging between the degree of openness and innovation performance. A mediating effect exists when the three conditions are satisfied (Baron and Kenny, 1986). Hypothesis 9c proposed that leveraging mediates the relationship between the degree of openness and innovation performance. Table 6.5.6

provides the testing results of mediation for leveraging via Baron and Kenny's (1986) method. Model 1 tested the first condition, which stated that the independent variable is correlated with the dependent variable. The results show that the degree of openness was significantly correlated to innovation performance ($\beta=0.556$, $p<0.001$). In model 2, the independent variable, the degree of openness, was regressed against the mediating variable, leveraging ($\beta=0.394$, $p<0.001$). Therefore, the degree of openness was correlated with leveraging, which confirmed the second condition. Model 3 tested whether the relationship between the degree of openness and innovation performance remained significant when the mediator, leveraging, was introduced into the initial relationship.

The results showed that both the degree of openness ($\beta=0.556$, $p<0.001$) and innovation performance ($\beta=0.354$, $p<0.001$) remained significant. However, the coefficients of the degree of openness on innovation performance decreased from 0.556 to 0.346. It indicated that the significance of the relationship between the degree of openness and innovation performance was reduced after leveraging was added to the analysis, which implies that leveraging partially mediates the relationship between the degree of openness and innovation performance. Furthermore, the control variables' overall combined effect is small and insignificant on innovation performance ($R^2 = 0.227$; $p \geq 0.05$). The control variables' overall combined effect is small and insignificant on innovation performance ($R^2 = 0.227$; $p \geq 0.05$).

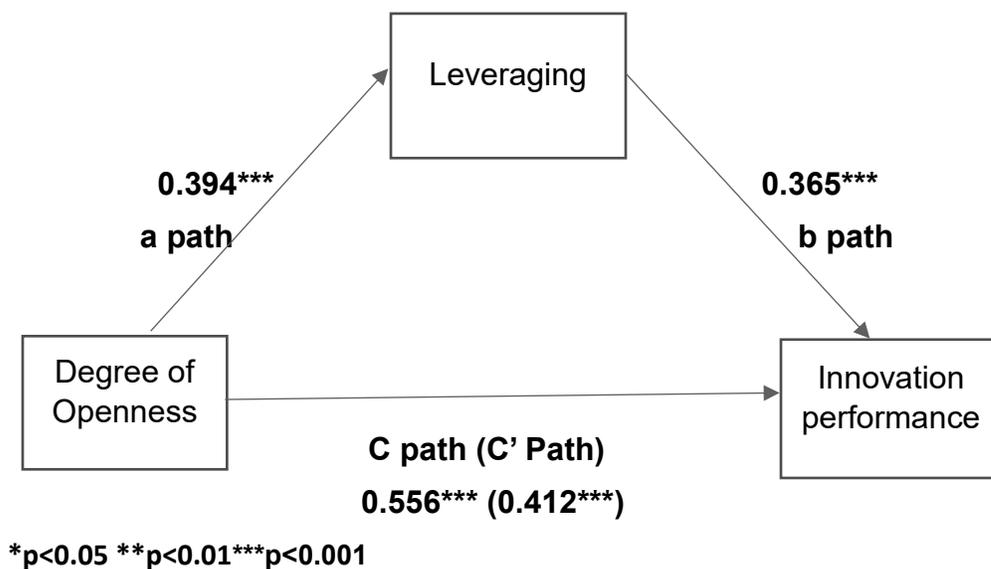
Table 6.5.6 Regression results for the mediating effect of leveraging on the relationship between degree of openness and innovation performance

	Innovation Performance	Leveraging	Innovation Performance
	Model 1	Model 2	Model 3
Control Variable			
Firm Size	0.000(0.032)	0.000(0.011)	0.001(0.065)
Firm Age	0.001(0.078)	0.001(0.068)	0.001(0.076)
Independent Variable			
Degree of openness	0.414***(0.556)	0.286***(0.394)	0.212***(0.346)
Mediator			
Leveraging			0.307***(0.365)
R ²	0.244	0.311	0.355
Adjusted R2	0.227	0.296	0.337
F Value	14.716	20.639	15.214

Note: N=141; * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$; Both unstandardised regression coefficients (B) and standardised regression (β) are shown in each equation ; ^a Natural Logarithm of the number of full-time employees.

This research further calculated the indirect mediation effect and total effect. As shown in Figure 6.9.7, the impact of leveraging on innovation performance is exerted via two routes. The first is the direct effect of leveraging on innovation performance (path c'). The second is the indirect effect (path ab=0.144 0.394*0.365) through leveraging. The results show that the indirect mediation effect accounts for 25.9% of the total mediation effect (0.144/0.556), suggesting leveraging of degree of openness partially and positively mediated the relationship between degree of openness and innovation performance, which supports hypothesis 9c.

Figure 6.9.7 The Mediating effect of the leveraging between the degree of openness and innovation performance



This finding is consistent with previous studies. The argument for hypotheses 9a, 9b and 9c assumes that structuring, bundling, and leveraging positively mediate the degree of openness and innovation performance relationship, and the results support the hypothesis. Parida, Westerberg and Frishammar (2012) state that adopting inbound-open innovation positively affects incremental and radical innovation in tech-oriented high-SMEs in Sweden. Through openness, these tech-oriented firms could acquire and accumulate valuable external resources to integrate into their innovation process to develop product and process innovations. Barrett, Dooley, and Bogue (2021) showed that high-tech SMEs in Ireland enhanced their technological innovation performance through inbound openness by assessing and accessing external resources and integrating the

same resources with internally controlled resources to support innovation activity. This process has allowed the SMEs to develop innovative products. Table 6.5.7 shows a summary of the hypothesis results.

To further confirm the mediation, the Sobel test was also carried out to confirm the significance of the mediated effect of the availability of technology resources, financial resources, networking capability and degree of openness (Sobel, 1982; Baron and Kenny, 1986). In the Sobel test, the mediated effect divided by its standard error yields a z-score of the mediated effect (Preacher and Kelley, 2011). This value was compared against a standard normal distribution to test for significance. If the z-score is greater than 1.96, it could be concluded that the effect is larger than expected by chance and is called significant. The standard error can be used to obtain confidence intervals around the mediated effect. The results confirmed that the mediating effects of the availability of technology resources ($z = 3.16 > 1.96$, $p < 0.01$), availability of financial resources ($z = 1.26 < 1.96$, $p > 0.01$), Networking capability ($z = 4.11 > 1.96$, $p < 0.01$), Degree of openness ($z = 3.84 > 1.96$, $p < 0.01$), Structuring {availability of technology resources} ($z = 3.79 > 1.96$, $p < 0.01$), Bundling {availability of technology resources} ($z = 3.13 > 1.96$, $p < 0.01$), Leveraging {availability of technology resources} ($z = 4.36 > 1.96$, $p < 0.01$), Structuring {availability of financial resources} ($z = 0.84 < 1.96$, $p > 0.01$), Bundling {availability of financial resources} ($z = 3.33 > 1.96$, $p < 0.01$), Leveraging {availability of financial resources} ($z = 3.22 > 1.96$, $p < 0.01$), Structuring {networking capability} ($z = 3.25 > 1.96$, $p < 0.01$), Bundling {networking capability} ($z = 3.84 > 1.96$, $p < 0.01$), Leveraging {networking capability} ($z = 5.24 > 1.96$, $p < 0.01$), Structuring {degree of openness} ($z = 3.77 > 1.96$, $p < 0.01$), Bundling {degree of openness} ($z = 2.94 > 1.96$, $p < 0.01$), Leveraging {degree of openness} ($z = 3.49 > 1.96$, $p < 0.01$). These results agree with previous mediation results calculated in previous sections in terms of the significance of the mediating variables. Below is the formula used to calculate the Sobel test, which was adapted from Mackinnon and Dwyer (1994) and Mackinnon, Warsi, and Dwyer (1995):

Sobel test equation, $z\text{-value} = a*b/\text{SQRT}(b^2*s_a^2 + a^2*s_b^2)$

a = raw (unstandardised) regression coefficient for the association between IV and mediator.

S_a = Standard error of a .

b = raw coefficient for the association between the mediator and the dependent variable (when the independent variable is also a predictor of the dependent variable).

S_b = Standard error of b .

Table 6.5.7 Summary of Hypotheses Testing

Hypothesis	Variables	Results
H1	Technology orientation is positively related to innovation performance.	Supported
H2	The availability of technological resources positively mediates the relationship between technology orientation and innovation performance.	Supported
H3	The availability of financial resources positively mediates the relationship between technology orientation and innovation performance.	Not Supported
H4	Networking capability positively mediates the relationship between technology orientation and innovation performance.	Supported
H5	The degree of openness positively mediates the relationship between technology orientation and innovation performance.	Supported
H6a	Structuring mediates the relationship between the availability of technological resources and innovation performance.	Supported
H6b	Bundling mediates the relationship between the availability of technological resources and innovation performance.	Supported
H6c	Leveraging mediates the relationship between the availability of technological resources and innovation performance.	Supported
H7a	Structuring mediates the relationship between the availability of financial resources and innovation performance.	Not supported
H7b	Bundling mediates the relationship between the availability of financial resources and innovation performance.	Supported
H7c	Leveraging mediates the relationship between the availability of financial resources and innovation performance.	supported
H8a	Structuring mediates the relationship between the networking capability resources and innovation performance.	Supported
H8b	Bundling mediates the relationship between the networking capability resources and innovation performance.	Supported
H8c	Leveraging mediates the relationship between the networking capability resources and innovation performance.	Supported

H9a	Structuring mediates the relationship between the degree of openness and innovation performance.	Supported
H9b	Bundling mediates the relationship between the degree of openness and innovation performance.	Supported
H9c	Leveraging mediates the relationship between the degree of openness and innovation performance.	Supported

6.7 Chapter Conclusion

This chapter has discussed the quantitative research findings based on the hypothesis development. This chapter presented the quantitative research's demographic statistics, correlations, and regression results. By examining 141 UK high-tech small businesses, this study examined the impact of the availability of technological resources, financial resources, networking capability and degree of openness on the relationship between technology orientation and innovation performance. Also, this study examined the mediating effects of structuring, bundling, and leveraging on the relationship between the availability of technological resources, financial resources, networking capability, degree of openness, and innovation performance. According to the proposed conceptual model (Chapter 4), the analysis is based on three parts. The first part shows the positive and significant relationship between technology orientation and innovation performance. In the second part, the availability of technological resources, networking capability and degree of openness are significantly and positively associated with innovation performance, while the availability of financial resources is significantly and negatively linked to innovation performance. In the third part, structuring, bundling and leveraging partially mediate the relationship between the availability of technological resources, networking capability and degree of openness. Whereas bundling and leveraging fully mediate the relationship between the availability of financial resources and innovation performance, structuring does not mediate the availability of financial resources and innovation performance relationship. Altogether, the result in this chapter supports 15 hypotheses of the proposed conceptual model and two hypotheses were rejected. These results have been very insightful, especially concerning how they influence high-technology SMEs.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This study aims to understand better the role of technology orientation and strategic firm resources in achieving innovation performance in UK high-tech small firms. This chapter summarises how this thesis answers the research questions and presents the findings of this study. Sections 7.2 and 7.3, 7.3.1 and 7.3.2 will present the key findings of the thesis. This is followed by section 7.4, which discusses the contributions to knowledge. Section 7.5 discusses the practical implications of this study. Section 7.6 presents the Limitations and Recommendations for Future Research, section 7.7 presents directions for future research, and section 7.8 concludes.

7.2 Findings of the Research

This research focused on answering the research questions by using quantitative methods. By analysing the quantitative data collected via the online survey that gathered the opinions of CEOs/senior managers of high-tech SMEs, Table 7.1 summarises key research findings.

Table 7.1 summarises the key research findings in this work.

Table 7.1 Summary of research findings

Research Questions	Hypothesis	Findings	Conclusion
RQ1: What is the relationship between technology orientation and innovation performance in high-tech IT SMEs in the UK?	H1: In high-tech firms, technology orientation positively affects innovation performance.	A high level of technology orientation could influence a firm to invest more in acquiring and integrating technologies into its R&D activities, resulting in more innovation outcomes.	Supported
RQ2: What is the role of strategic firm resources in the relationship between technology orientation and innovation performance in high-tech SMEs in the UK?	H2: In high-tech firms, technological resources mediate the relationship between technology orientation and innovation performance	High-tech firms with technological resources are more likely to invest in innovation activities and achieve innovation performance.	Supported
	H3: In high-tech firms, the availability of financial resources mediates the relationship between technology orientation and innovation performance.	High-tech firms with financial resources are more likely to invest in innovation activities and achieve innovation performance.	Not Supported
	H4: In high-tech firms, networking capability mediates the relationship between technology orientation and innovation performance.	A firm's networking capability allows it to utilise a network of actors to lower the cost of production, collaborate on innovations, and develop new products or services.	Supported
	H5: In high-tech firms, the degree of openness mediates the relationship between technology orientation and innovation performance.	A firm's openness allows it to overcome resource scarcity by partnering with external sources to acquire resources and transform them into new products or services.	Supported

<p>RQ3: What is the role of structuring, bundling, and leveraging between the availability of technological resources, financial resources, networking capability and openness and innovation performance in high-tech SMEs in the UK?</p>	<p>H6a: Structuring positively mediates the relationship between the availability of technological resources and innovation performance.</p>	<p>Resource structuring, acquiring, accumulating, and divesting into more technological resources could transform these technological resources into more innovative performance.</p>	<p>Supported</p>
	<p>H6b: Bundling positively mediates the relationship between the availability of technological resources and innovation performance.</p>	<p>Through bundling, technological resources could be converted to capabilities essential for developing new products and processes and achieving innovation performance.</p>	<p>Supported</p>
	<p>H6c: Leveraging positively mediates the relationship between the availability of technological resources and innovation performance.</p>	<p>High-scale firms could achieve more innovation performance through mobilising and deploying technological resources.</p>	<p>Supported</p>
	<p>H7a: Structuring positively mediates the relationship between the availability of financial resources and innovation performance.</p>	<p>Acquiring and accumulating financial resources in a firm is insufficient to guarantee that internally available resources can</p>	<p>Not Supported</p>

		be transformed into more innovative performance.	
	H7b: The bundling positively mediates the relationship between the availability of financial resources and innovation performance.	The appropriate bundling of financial resources in a firm is sufficient to guarantee that a high-tech firm can achieve some innovative performance.	Supported
	H7c: Leveraging positively mediates the relationship between the availability of financial resources and innovation performance.	Through appropriate mobilising and deploying of available financial resources, high-tech firms could achieve more innovation performance.	Supported
	H8a: Structuring positively mediates the relationship between networking capability and innovation performance.	A high-tech firm's networking capability could help it acquire and accumulate resources to achieve more innovative performance through structuring.	Supported
	H8b: Bundling positively mediates the relationship between networking capability and innovation performance.	A high-tech firm's networking capability could help it develop more capabilities to achieve innovative performance through bundling.	Supported

	H8c: Leveraging positively mediates the relationship between networking capability and innovation performance.	Mobilising and deploying a high-tech firm's networking capability could enhance its innovation activities and achieve higher innovation performance.	Supported
	H9a: Structuring positively mediates the relationship between the degree of openness and innovation performance.	A high-tech firm's degree of openness enhances its innovation performance through structuring.	Supported
	H9b: Bundling positively mediates the relationship between the degree of openness and innovation performance.	Managers of high-tech firms, through bundling, can use their degree of openness to enhance their innovation performance.	Supported
	H9c: Leveraging positively mediates the relationship between the degree of openness and innovation performance.	By mobilising and deploying their degree of openness, managers of high-tech firms can achieve innovative performance.	Supported

This research examines the impact of technology orientation on innovation performance and the role of firm resources during this process. Also, this research investigates the role of resource orchestration in the relationship between technology orientation and innovation performance. Moreover, this study also confirms that more technology orientation could lead to greater innovation performance. Technology orientation could influence innovation performance more through strategic firm resources. In addition, firms can achieve more innovative performance by structuring, bundling, and leveraging technological resources, financial resources, networking capability, and degree of openness.

7.3 Technology orientation and Innovation performance

In Chapter 4, the impact of technology orientation on innovation performance is examined; with the data from the online survey of 141 small to medium-sized UK high-tech firms, this study finds that technology orientation impacts innovation performance. These research findings add to the UK high-tech business literature by enriching the understanding of the relationship between technology orientation and innovation performance in UK high-tech Firms. In addition, they contribute to the application of resource-based views and resource orchestration theory in high-tech business studies. The following section summarises the impact of different dimensions of strategic firm resources on the relationship between technology orientation and innovation performance.

7.3.1 The role of strategic firm resources between technological orientation and innovation performance

This thesis examines the relationship between technological orientation and innovation performance and explores how firm resources affect this relationship. Through an in-depth analysis of quantitative chapter 4, the findings show that the availability of firm resources could mediate the relationship between technology orientation and innovation performance, with only one exception: financial resources. These research findings

contribute to the high-tech business innovation literature by unravelling the role of firm resources in innovation.

Role of availability of technological resources

One of the firm resources that influence the relationship between technology orientation and innovation performance is technological resources. The quantitative results revealed that technological resources partially and positively mediate the relationship between technology orientation and innovation performance. Further, more expenditure on technological resources and innovation activities could create new products or services. Accordingly, the research results suggested that the availability of technological resources could partially mediate the relationship between technology orientation and innovation performance.

Role of availability of financial resources

The second firm resource is the availability of financial resources. Regarding the mediation role of the availability of financial resources between technology orientation and innovation performance, the finding was unexpected and suggested that the availability of financial resources has limited or no influence on the relationship between technology orientation and innovation performance. The quantitative results indicated that the relationship between technology orientation and innovation performance is insignificant. A possible explanation for this could be that high-tech firms can still carry out R&D activities because the competitive advantage of high-tech firms resides in their behavioural resources instead of financial resources (Freel, 2000). Berends *et al.* (2014) argued that high-tech firms' innovation activities depend more on knowledge and spillovers instead of financial resources. As such, small-scale high-tech firms may not necessarily worry about more financial resources, which may not affect their influence on innovation performance. This is consistent with the study of Berends *et al.* (2014)

Role of availability of networking capability

Another strategic firm resource is network capability. According to the quantitative results, networking capability partially mediated the relationship between technology orientation and innovation performance. Networking capability could transform this process (Bierly,

Lii and Daly, 2007), transforming technology orientation into innovation performance. Networking capability could enable access and cooperation among a network of actors with vital resources for innovation, thereby creating new innovative products and services. As a result, the research result revealed that networking capability could partially mediate the relationship between technology orientation and innovation performance.

Role of degree of openness

Regarding the mediating role of the degree of openness between technology orientation and innovation performance. The quantitative results found a partial and positive mediating effect on the degree of openness between technology orientation and innovation performance. Openness allows firms to open their firm boundaries to access more external resources, gain technological ideas, skills, and knowledge, and integrate some of the knowledge into firm innovation processes and activities. Through openness, technology orientation indirectly influences innovation performance. Therefore, the research result confirmed a partial and positive mediating effect between technology orientation and innovation performance.

Availability of strategic firm resources and Innovation performance

This research examines the relationship between firm resources and innovation performance. According to the quantitative results, a positive and significant correlation was found except for the availability of financial resources, which was not positive and insignificant. Investing resources in innovation activities contributes to developing innovative products (Lee, Wu, and Pao, 2014). Some studies have argued that the presence of internal strategic resources positively affects the process of innovation (Penrose, 1959; Barney, 1991; O'Cass and Sok, 2014; Demirkan, 2018). Continued development and acquisition of different resources, such as external knowledge sources, software, and new machines, which can be combined and integrated with internal resources and capabilities, can create situations to develop product innovation (Escribano, Fosfuri and Tribó, 2009; Rosenbusch, Brinckmann and Bausch, 2011). Therefore, this study suggested that higher available strategic firm resources result in greater innovation performance.

The role of resource orchestration between the availability of strategic firm resources and innovation performance

Moving forward, this thesis further examines the relationship between the availability of firm resources and innovation performance and how resource orchestration influences this relationship. Sirmon *et al.* (2010) argued that a firm can achieve an advantage over competitors if firm resources and capabilities are optimally orchestrated. The findings are presented through an in-depth analysis of quantitative data. Firstly, higher orchestration of firm resources could lead to more significant innovation outcomes. Secondly, structuring, bundling, and leveraging could mediate the relationship between the availability of firm resources and innovation performance. These results contribute to the high-tech business innovation literature by unveiling the role of resource orchestration between the availability of firm resources and innovation performance.

Structuring, Bundling and Leveraging (Availability of Technological Resources).

A firm's availability of technological resources could be used to achieve innovation performance through structuring, bundling, and leveraging. Regarding the mediation role of structuring between the availability of technological resources and innovation performance, the quantitative results found a partial and positive mediating effect of structuring between the availability of technological resources and innovation performance. These results show that even though internal resources are important to a firm, managers must acquire and accumulate more resources and divest some resources that could give a firm a competitive advantage through their innovative results. Structuring enables firms to acquire diverse vital resources from external sources to complement internal resources and thus trigger more innovative activities, which could create more innovative products and services (Lin *et al.*, 2010; Gu, Jiang, and Wang, 2016; Carnes *et al.*, 2017; Deligianni *et al.*, 2019).

Regarding the mediation role of bundling between the availability of technological resources and innovation performance, the quantitative results found a partial and positive mediating effect of bundling between the availability of technological resources and innovation performance. These results show that even though internal resources are important to a firm, more importantly, it is bundling through stabilising, enriching, and

pioneering resources into firm capabilities that create a sustainable competitive advantage (Sirmon et al., 2010). bundling enables firms to bundle diverse vital internal and external resources into different capabilities. These capabilities are needed to carry out R&D activities that will create innovative outcomes that can cause incremental and radical organisational change in addition to value (Hamel and Prahalad, 1994; Sirmon *et al.*, 2007).

Regarding the mediation role of bundling between the availability of technological resources and innovation performance, the quantitative results found a partial and positive mediating effect of leveraging between the availability of technological resources and innovation performance. The quantitative results indicated that the relationship between technology orientation and innovation performance is significant. These results show that even though internal strategic resources and bundles of capabilities are vital to a firm, more importantly, it is leveraging through mobilisation, coordination, and deployment to exploit a firm's capabilities and taking advantage of market opportunities to satisfy customers (such as delivering innovative results) thereby creating value for the firm, is what creates a sustainable competitive advantage (Sirmon *et al.*, 2010).

Structuring, Bundling and Leveraging (Availability of Financial Resources).

When it comes to how a firm's financial resources could be converted to innovation performance, the role of structuring is not significant. The quantitative results found an insignificant and negative effect of structuring between the availability of financial resources and innovation performance. This suggests that structuring is not a key factor in achieving innovation performance. High-tech firms may not necessarily need more financial resources to innovate, as they could depend on internal knowledge and skills to achieve innovation performance instead of financial capital (Katila and Shane, 2005).

Bundling is how a firm integrates resources within its portfolio to create capabilities. Through this process, a firm may achieve a competitive advantage over rivals resulting from the value created (Sirmon et al., 2010). Regarding the mediation role of bundling between the availability of financial resources and innovation performance, the quantitative results found a significant and full mediating effect of bundling between the availability of financial resources and innovation performance. These results show that

bundling financial resources into financial capability is necessary for small firms to engage in scientific research, development, process, and product innovation (Perez-Alaniz *et al.*, 2023).

Leveraging is the mobilisation, coordination, and deployment of financial resources. A firm can develop innovative solutions and products through this process, leading to a competitive advantage over rivals (Sirmon *et al.*, 2010). Regarding the mediation role of leveraging between the availability of financial resources and innovation performance, the quantitative results found a full mediating effect of leveraging between the availability of financial resources and innovation performance. More specifically, the quantitative results indicated that the only way for a firm to achieve innovation performance is for the available resources to be highly leveraged (Sirmon *et al.*, 2010).

Structuring, Bundling and Leveraging (Networking Capability).

One of the ways a firm's networking capability could be converted to innovation performance is through structuring, bundling and leveraging. The quantitative results found a partial and positive mediating effect of structuring between networking capability and innovation performance regarding the mediation role of structuring between networking capability and innovation performance. These results show that structuring by managers is essential, and this could give a firm a competitive advantage through their innovative results. Structuring enables firms to build networks to acquire technological ability (Ahuja, 2000; Sung, 2005), contributing to innovation outcomes (Tödtling & Kaufmann, 2002; Rogers, 2004; Deligianni *et al.*, 2019). Therefore, networking capability could influence innovation performance through effective structuring. This reiterates the importance of structuring by managers, empowering them and making them feel in control of the process.

Regarding the mediation role of bundling between networking capability and innovation performance, the quantitative results found a partial and positive mediating effect of bundling between networking capability and innovation performance. These results show that it is bundling, depending on the needs of the firm, 'enriching' such as further improving the firm's networking capabilities by adopting up-to-date technologies from

external networks to solve complex technological problems and create new products and services (Hamel and Prahalad, 1994; Sirmon *et al.*, 2007; 2010).

Leveraging is another essential factor in the relationship between networking capability and innovation performance. In terms of the mediation role of leveraging between networking capability and innovation performance, the quantitative results found a partial and positive mediating effect of leveraging between networking capability and innovation performance. More specifically, the research finding indicated that leveraging partially mediates the relationship between networking capability and innovation performance.

Structuring, Bundling and Leveraging (Degree of openness)

One of the ways a firm's degree of openness could be converted to innovation performance is through structuring, bundling and leveraging. Regarding the mediation role of structuring between the degree of openness and innovation performance, the quantitative results found a partial and positive mediating effect of structuring between the degree of openness and innovation performance. High-tech small firms have cutting in-house technology but have no technical capabilities to transform the technology into a successful business (Vanhaverbeke, Vermeersch, and De Zutter, 2012). They must cooperate with external partners to innovate successfully and achieve a competitive advantage (Vanhaverbeke, Vermeersch, and De Zutter, 2012). Therefore, openness is the right step for many small firms. Through structuring, firms search for more external resources by engaging in open innovation by collaborating with companies, universities, research institutions and startups to share resources and knowledge and create joint innovative solutions (Maxwell, 2006; West and Bogers, 2017). Thus, the research finding confirmed a partial and positive mediating effect between the degree of openness and innovation performance. This highlights the crucial role of openness and collaboration with external partners in creating joint innovative solutions.

Regarding the mediation role of bundling between the degree of openness and innovation performance, the quantitative results found a partial and positive mediating effect of bundling between the degree of openness and innovation performance. These results show that it is bundling to create capabilities and more capabilities needed to solve complex technological problems, thereby creating innovative products and services that

result in a sustainable competitive advantage (Sirmon *et al.*, 2007; 2010). Thus, the research finding confirmed a partial and positive mediating effect between the degree of openness and innovation performance.

Leveraging is another important factor in the relationship between the degree of openness and innovation performance. In terms of the mediation role of leveraging between the degree of openness and innovation performance, the quantitative results found a partial and positive mediating effect of leveraging between openness and innovation performance. The research findings showed that leveraging the collective intelligence and diversity of knowledge and skills of external partners to gather more data, participate in collaborative projects to save cost, generate innovative ideas and perform complex tasks such as developing new technological innovation (Pollok, Lüttgens, and Piller, 2019). Through leveraging, the degree of openness indirectly influences innovation performance. Thus, the research finding confirmed a partial and positive mediating effect between the degree of openness and innovation performance.

7.3.2 Comparative Assessment of research findings in UK high-tech small business

Although there has been growing interest in innovative high-tech small businesses, most studies are conducted in Asian countries, and few are in the UK. Understanding the role of technology orientation, strategic firm resources, and its orchestration to achieve innovation performance in UK high-tech SMEs remains inadequate. There are some previous studies still conducted in the UK (Romijn and Albu, 2002; Freel, 2005; Oke, 2007; Oluwafemi, Mitchelmore, and Nikolopoulos, 2020; Barrett, Dooley, and Bogue, 2021; Shamroz *et al.*, 2021). For example, Romijn and Albu, 2002 investigated various potentially vital internal and external sources of innovative capability in small high-technology firms in Southeast England. It also examined whether their geographical location improved their innovation performance. They found that science-based start-ups benefit from scientific institutions located in the same region as sources of innovative ideas, contributors to innovative processes, and foster technology-driven leaders who can build successful firms that can achieve competitive advantage based on innovations that

can be patented. In contrast, high-tech-oriented small firms engaging in some openness are positively related to innovation performance. Likewise, Shamroz *et al.*, 2021 focused on the antecedents of innovation and its contribution to business performance. A single case study approach and a qualitative data analysis method were adopted. Manufacturing firms were chosen as they are innovative. The findings revealed that identifying and implementing new and innovative ideas and resources for capturing new opportunities is essential (Arthurs and Busenitz, 2006). Also, existing knowledge in the firm is an essential prerequisite for the process of innovation and is a function of the innovative capability of a firm.

Additionally, Mawson and Brown (2017) investigated the dynamics of entrepreneurial acquisitions (conceptualised as an advanced stage of the outside-in 'open innovation' strategy) by 353 Scottish high-growth SMEs. Drawing on data from Scottish firms, they found that acquiring external resources allows them to acquire knowledge and technology complementarities to become top and high-growth technology-based firms. Wang and Costello (2009) examined innovation in two ICT small businesses in the West Midlands. They used a case method approach and investigated the effect of firm resources, organisational culture, structure, and market dynamism on firm-level innovation. They found that firm-level innovation is influenced by market dynamism, and innovation intensity depends on financial and human resources availability. Moreover, an organisational culture supports new product development, and an innovation-conducive structure/mechanism influences the innovation results. Overall, studies in the literature investigate UK high-tech firms' innovation from multiple sides, including involvement of ambidextrous leadership (Oluwafemi, Mitchelmore, and Nikolopoulos, 2020), Open Innovation (Audretsch and Belitski, 2020; Barrett, Dooley, and Bogue, 2021), Knowledge (Alegre, Sengupta, and Lapiedra, 2013; Savic *et al.*, 2020), Entrepreneurship (Smith and Romeo, 2012; Brown and Mason, 2014). However, understanding how resource orchestration influences innovation performance within UK small high-tech firms is limited, especially in how strategic firm resources are structured, bundled, and leveraged to achieve innovation performance.

In contrast to previous studies, this thesis provides a more nuanced picture of UK high-tech business technology orientation, innovation performance and the orchestration of strategic firm resources, from its antecedents to the resulting outputs. The findings highlight the crucial role of technological resources, financial resources, networking capability and degree of openness. Secondly, this study also examines the effect of resource orchestration (structuring, bundling, and leveraging) on the relationship between the availability of strategic firm resources and innovation performance. The finding further highlights that resource orchestration by managers of high-tech SMEs is more important than just the availability of resources.

7.4 Contributions to Knowledge

7.4.1 Theoretical contribution of this study

This thesis investigated the influence of technology orientation on innovation performance and the impact of the availability of strategic firm resources on this relationship. Further, the role of resource orchestration was examined concerning the availability of strategic firm resources and innovation performance in UK high-tech SMEs.

Based on the research findings, this study contributes to the existing theories and literature by filling the research gaps. A fundamental theory used in this study is the RBV, which states that if resources are valuable, rare, inimitable, and not easily substituted, a firm can achieve a competitive advantage over rivals; this advantage over rivals usually results from some innovation performance (Friar, 1995; Maziti, Chinyamurindi, and Marange, 2018; Farida and Setiawan, 2022). This study contributes to RBV by building on the findings from high-tech SMEs in developed markets; we have gained new insights that were previously unknown.

This study showed from empirical results that technology orientation has a positive and significant relationship with innovation performance in high-tech small firms. This contributes to knowledge as it establishes that the more a high-tech small firm is technology-oriented, the more innovative performance it will achieve.

Generally, the contribution relates to the innovation performance conundrum in high-tech SMEs. While previous studies have documented that high-tech SMEs could achieve successful innovation with some available firm resources (Ju, Ferreira, and Wang, 2020; Cowling, Liu, and Zhang, 2021; Choi, Ha, and Kim, 2022; Cui, Ye, & Tan, 2022; Temouri *et al.*, 2022). For example, Cui, Ye, and Tan, 2022 analysed the paradox of high-tech SMEs, claiming that high-tech SMEs can innovate if firm resources are available and well-orchestrated. This thesis contributes to the theory by showing that small high-tech firms that are technology-oriented in the UK can achieve innovation performance with strategic firm resources that are valuable, rare, inimitable, and non-substitutable.

Specifically, this study contributes to knowledge by establishing the effect of the availability of technology resources on the relationship between technology orientation and innovation performance. The study demonstrates that the availability of technological resources that are valuable, rare, inimitable, and non-substitutable significantly impacts the relationship between technology orientation and innovation performance in high-tech SMEs. This means that the availability of technology resources enhances the innovation performance of high-tech SMEs, and this contributes to knowledge by developing and empirically validating a conceptual framework about the effect of the availability of technology resources on the relationship between technology orientation and innovation performance. Therefore, a small, high-technology firm can enhance its innovative performance by investing more technological resources. These findings support the argument of RBV.

There is a further contribution to knowledge by examining the effect of the availability of financial resources on the relationship between technology orientation and innovation performance. The study reveals that the availability of financial resources does not affect the relationship between technology orientation and innovation performance in high-tech SMEs. This means that a firm with financial resources is not guaranteed to achieve innovation performance; instead, other resources and capabilities can compensate for their limited financial resources. Possessing financial resources is not enough to achieve innovation performance in high-tech SMEs; instead, strategically using resources is more critical (Sirmon *et al.*, 2007; Jissink, Schweitzer, and Rohrbeck, 2019). This study also

contributes to knowledge by developing and empirically validating a conceptual framework about the role of the availability of financial resources on the relationship between technology orientation and innovation performance. These findings support the argument of RBV.

Furthermore, this study contributes to knowledge by examining the role of networking capability in the relationship between technology orientation and innovation performance. Whilst studies in the literature have shown that firms can achieve successful innovation with networking capabilities (Ritter, 1999; Ritter, Wilkinson, & Johnston, 2002; Niesten and Jolink, 2015; Fang *et al.*, 2019), the internal mechanism of the role of networking capability in the nexus between technology orientation and innovation performance in developed markets like the UK has not been investigated. Examining the role of networking capability in the relationship between technology orientation and innovation performance reveals that networking capability positively impacts the relationship between technology orientation and innovation performance in high-tech SMEs. This result further suggested that a small high-tech firm with a network capability that is superior to competitors or whose networking capability can easily be copied can enable it to enhance its innovative performance. This study offers a significant contribution to strategic management research by suggesting that a higher networking capability plays a crucial role in unlocking the potential value of network resources. These findings support the argument of RBV.

There is a further contribution to knowledge by examining the effect of the degree of openness on the relationship between technology orientation and innovation performance. It is common knowledge that small firms typically suffer from resource poverty and, as a result, need to open their firm boundaries to collaborate with external partners for benefits such as sharing the cost of product development, access to highly skilled employees and increasing mobility of knowledge (Chesbrough, 2003a, b; Afuah, 2003; West *et al.*, 2006). This study extends the existing literature by showing that openness towards external partners such as customers, research institutions and universities positively and significantly influences the innovation performance of high-tech SMEs and these results support the argument of RBV.

While high-tech SMEs literature has increased its interest in the way resource orchestration (structuring, bundling and leveraging) plays an essential role in shaping high-tech small business innovation (Carnes *et al.*, 2017; Lamont *et al.*, 2018; Cui *et al.*, 2022; Temouri *et al.*, 2022; Ma *et al.*, 2023), extant studies primarily focused on the direct relationship between the composition of resource orchestration characteristics and innovation (Carnes *et al.*, 2017; Lamont *et al.*, 2018; Andersén and Ljungkvist, 2021; Bittencourt, dos Santos, & Mignoni, 2021). However, a gap remains in identifying the role of managers in orchestrating (structuring, bundling and leveraging) strategic resources in high-tech SMEs. With data from 141 UK high-tech SMEs, this thesis contributed to the ROT by building on the findings from high-tech SMEs in developed markets with new previously unknown insights. The findings revealed the role of resource orchestration (structuring, bundling and leveraging) in the relationship between the availability of strategic firm resources and innovation performance. Specifically, this thesis contributes to ROT by examining the indirect role of structuring, bundling and leveraging between the availability of strategic firm resources and innovation performance in high-tech firms, which provides new empirical findings for the relationship between available strategic firm resources and innovation performance in small high-tech firms. These results show that small high-tech firms can achieve innovation performance more than competitors through effective orchestration of strategic firm resources.

Regarding the availability of technology resources, the findings show that resource orchestration (structuring, bundling and leveraging) significantly and positively impacts the nexus between the availability of technology resources and innovation performance in UK high-tech SMEs. This demonstrates that the efficient orchestration of technology resources leads to higher innovation performance. This contributes to knowledge as no prior models or studies have investigated this. Concerning the orchestration of the availability of financial resources. The results show that structuring does not significantly and positively influence the relationship between the availability of financial resources and innovation performance, while bundling and leveraging positively affect the availability of financial resources on innovation performance in UK high-tech SMEs. The findings show that possessing and acquiring financial resources does not lead to

innovation performance; instead, bundling and leveraging puts a firm in a position to achieve innovation performance.

Regarding networking capability, the result shows that structuring, bundling, and leveraging a firm's networking capability significantly and positively impact the nexus between networking capability and innovation performance in UK high-tech SMEs. The more networks a firm can develop, build, and utilise, and with strong ties, the more high-tech firms can achieve innovation performance. This contributes to knowledge as no prior models or studies have investigated this. Regarding the degree of openness, the result shows that structuring, bundling, and leveraging a firm's openness has a significant and positive impact on the nexus between the degree of openness and innovation performance in UK high-tech SMEs. The more a high-tech firm can open its firm boundaries to seek external resources, the higher its chance of achieving innovation performance. This contributes to knowledge as no prior models or studies have investigated this. This provides additional empirical data on this relatively unexamined field.

Lastly, this research combines the resource-based view and resource orchestration theory in high-tech small businesses. Despite the relatedness of the resource-based view because of the relevance of firm resources to the firm (Ahn, Kim, and Lee, 2022), past studies using the theoretical lens focus on the direct influence of different resources (Yang, Xun, and He, 2015; Gu, Jiang, and Wang, 2016). This research extends the scope by examining the roles of complementarity and interaction between technological resources, financial resources, networking capability, and degree of openness. The research findings demonstrate that high-tech SMEs benefit from the RBV lens, where high levels of availability of strategic firm resources in technology-oriented firms aid innovation performance. This research also enriches the resource orchestration theory in high-tech small businesses by integrating structuring, bundling, and leveraging as mediators between the availability of strategic firm resources and innovation performance. Resource orchestration perspectives suggest that the managers' role in orchestrating a firm's strategic resource affects firm innovation by achieving a sustainable competitive advantage (Sirmon *et al.*, 2007, 2010). Based on resource orchestration theory, this study probes more deeply into the relationship between the availability of firm

resources and innovation performance, identifying the conduits by which resource orchestration works during the innovation process. As such, it provides new insight into the relationship of resource orchestration (structuring, bundling, and leveraging) in high-tech small business innovation performance, thereby elaborating knowledge of innovation and resource orchestration in high-tech small businesses.

Lastly, this study also makes a significant methodological contribution to the literature through the adoption of a quantitative research method to examine the impact of resource orchestration (structuring, bundling, and leveraging) on the relationship between technology orientation, availability of strategic firm resources and innovation performance in the UK high-tech SMEs. A critical literature review showed that previous research on resource orchestration for innovation has majorly relied on qualitative methods (Bittencourt, dos Santos, & Mignoni, 2021; Cui *et al.*, 2022; Tikas, 2023). The quantitative strategy allows the gathering of data based on surveys. The use of survey questionnaires is a significant methodological contribution.

7.5 Practical implication of this study

Employing a sample of 141 UK high-tech SMEs, we aim to assess their inbound open innovation framework and the effects on innovation performance. Specifically, we looked at the contribution of collaborating with partners like universities and research centres (Spencer, 2001; Fontana, Geuna, and Matt, 2006) and other companies (e.g., Shin, Kim, and Park, 2016; Shin, Park, & Park, 2019). However, different from previous studies that looked at their effects either on product and process innovation or innovation performance (this latter often measured with product or patent number) separately, we looked at the impact of different R&D collaborations on both the exploration as well as the exploitation side of the SMEs innovation process (Freel, 2005; Stone *et al.*, 2008). Our findings provide SME managers and business owners valid indications to make their OI inbound strategy more effective (Laursen and Salter, 2006; van de Vrande *et al.*, 2009; Vanhaverbeke, 2012; Vanhaverbeke *et al.*, 2017) given the highlighted need to align different R&D partners with various outcomes and expectations (Theyel, 2013; Hyll and Pippel, 2016).

In addition to its theoretical contributions, this thesis offers a wealth of practical insights that can empower high-tech business practitioners and policymakers in their decision-making processes.

Implications for high-tech small business owners, managers, or advisors

Firstly, this thesis extends the understanding of how the availability of strategic firm resources could lead to enhanced innovation performance in technology-oriented firms. It gives practitioners practical knowledge of how such tendencies might frame their innovativeness. Specifically, the findings of this thesis reveal that the availability of firm resources has multiple effects on the innovation performance of technology-oriented SMEs. From a managerial perspective, pursuing new products, services, and processes involves SMEs searching for resources to improve operational success. One way aside from internal firm resources is by searching to learn from external sources, such as universities, suppliers, and competitors. Of course, obtaining resources from different external sources will not automatically lead to an innovation performance. While there is evidence that broad firm resources play a significant role in the development of new products, services and processes, SMEs also need to focus on the managers' role and the related internal mechanisms that are important for enhancing the transformation of externally sourced firm resources into new products, services, and processes. SMEs can improve their competitive positions by developing and implementing strategies combining external and internal resources. In choosing an innovation strategy, SMEs should carefully assess their internal resources in scale and attributes and their access to external resources. SMEs should create innovative approaches to align with their resource configuration. Finally, our study highlights the importance of SMEs operating under some limitations to seek new sources of resources outside their boundaries to achieve their firm objectives, such as innovation performance. Further, a deeper understanding of the efficiency of converting technology orientation to innovation performance is crucial for managers and advisors of high-tech SMEs.

This thesis confirms the indirect effects of the availability of strategic firm resources on the relationship between technology orientation and innovation performance. Technological resources, networking capability, and degree of openness assist in

converting technology orientation to innovation performance, except for financial resources, which were not confirmed. The reason for this has already been explained in the research findings section. This thesis also confirmed the indirect effects of resource orchestration on the relationship between the availability of strategic firm resources and innovation performance. Structuring, bundling, and leveraging assist in converting resource availability to innovation performance. As such, practitioners and managers of high-tech SMEs may consider creating the right environment and investing more in acquiring relevant resources needed in the innovation process. Furthermore, managers of high-tech SMEs should increase their spending on innovation activities to maintain experienced and skilled staff, constantly update their skills, and develop the knowledge needed to utilise the resources appropriately. Consequently, their firms can produce competitive and innovative products.

For policymakers, the implication is the enhancement of gathering resources to support high-tech SME operations and innovation development. Managers of high-tech SMEs consistently require knowledge and information from external resources to develop effective transformation from technology orientation to innovation performance. However, it is difficult for high-tech SMEs to access this support. Thus, the government could establish or fund more institutions that would support high-tech firms to help them develop capabilities in using knowledge and skills.

Policymakers should assist UK high-tech small firms in enhancing their capability of using knowledge and skills. Therefore, this research suggests that government incentives should adopt different approaches to business operations and innovation activities, such as consolidating internal resources. Also, strengthening the partnerships between research institutions and universities could serve as valuable sources of resources for high-tech firms. The policymakers could enact new policies and strengthen existing policies to improve the university-industry linkage and encourage researchers in universities to participate in projects led by firms in the UK. In doing so, UK universities and UK small high-tech firms can effectively exchange information and knowledge, enhancing the process of innovation.

7.6 Limitations and Recommendations for Future Research

7.6.1 Research Limitations

While the results of this research provide primary contributions to academia and practice, this thesis still contains some limitations that require further investigation.

This study focuses on innovation in high-tech firms. The FAME database provided a list of small high-tech firms in the UK. Nevertheless, access to contact information in the database was limited, so other means of contacting respondents, such as LinkedIn, were used. Due to this limitation, conducting a conventional representative sample survey is not easy. This study adopted the stratified random sampling technique, where the researcher used contacts to distribute questionnaires. Although this approach provided an effective way to contact respondents, it may hinder the generalizability of the study. Moreover, this study uses quantitative evidence to explore technology orientation and innovation and identifies drivers of and barriers to innovation performance in high-tech SMEs in the UK. Some results do not support what was initially hypothesised, and to understand the reason for this, it is suggested that fine-grained qualitative research be conducted to generate more insights on how the role of availability and orchestration of strategic firm resources influences the technology orientation and innovation performance relationship.

One of the study's limitations is that it only involves the firm's top management. While these individuals are vital decision-makers on technology acquisition, strategy, firm resources, and innovation, including various employee perspectives could have enriched the study's findings and strengthened its framework. Another limitation is using cross-sectional data from a sample of 141 high-tech SMEs operating in the UK. Zellweger and Sieger (2012) have suggested that innovativeness may fluctuate over time. Therefore, it would be beneficial for future research to consider a longitudinal study (3yr—5yr) to gain a more comprehensive understanding of the relationship between technology orientation, strategic firm resources, resource orchestration, and innovation performance. Another limitation of the study is the small sample size. Thus, the issue of sampling error from the sample size is a limitation of the study.

Lastly, this study examined high-tech SMEs' technology orientation, strategic firm resources, and innovation performance. This study did not capture the role of large businesses in the sector (e.g., software firms or telecommunication firms), which, in many cases, are the main customers of these SMEs. Loane and Bell (2009) and Sui and Baum (2014) acknowledge the role played by a firm's clients in supplying resources. Also, other sectors, such as pharmaceutical, production, education and finance, should be investigated aside from high-tech firms. Therefore, this is a gap that needs further investigation.

7.7 Directions for Future Research

This thesis also provides some opportunities for future research. To begin with, this research model examines the effect of technology orientation on innovation performance, the mediating effect of availability of strategic firm resources on technology orientation and innovation performance, and the mediating effect of resource orchestration (structuring, bundling, and leveraging) on availability of strategic firm resources and innovation performance. Future studies could extend this model to countries with similar dynamics and developing markets. It could advance understanding of how high-tech small businesses can innovate and thrive in the markets.

Moreover, the mechanisms underlying technology orientation and innovation performance are worth further examination. This study first examines the indirect effects of the availability of strategic firm resources in high-tech firms. It focused on the impact of four strategic firm resources between technology orientation and innovation performance. Given the high level of shared understanding and dynamic environment in which high-tech firms operate, we focus on four strategic firm resources: technological, financial, networking capability and degree of openness. Future studies thus can extend our model to other aspects of strategic firm resources, such as knowledge, physical, and human resources. Due to the prominent role of firm resources in high-tech firms, future research might investigate the potential effects of other firm resources on conversion from technology orientation to innovation performance in small high-tech firms, which could provide new insights. Another future direction of this study is to examine the extent to

which the independent variable and other variables affect different types of innovation such as incremental and radical innovation more in-depth.

This research is theoretically based on RBV and ROT. However, many changes are occurring in the world market, including how SMEs operate. Dynamic changes in technology and communication are creating new avenues for SMEs to acquire resources and capabilities, and future research needs to look at technology orientation from these new business models' perspectives.

7.8 Conclusion

Given the complexity of high-tech innovation, this study employs a quantitative method to deepen the understanding of the innovation process in UK small high-tech businesses. Drawing on resource-based theory and resource orchestration theory, it investigates how technology orientation influences innovation performance and the role of the availability of strategic firm resources and resource orchestration in this conversion. The growing body of literature on the influence of the availability of strategic firm resources on innovation performance shows that findings are sometimes contradictory to each other. Apart from a few studies from the UK on the availability of firm strategic resources and innovation performance in technology-oriented small firms, there are few studies investigating whether the availability of strategic firm resources has an impact on the relationship between technology orientation and innovation performance of small high-tech firms (Buenechea-Elberdin, Kianto, and Sáenz, 2018; Senaratne and Wang, 2018). There is also a shortage of empirical studies investigating the role of resource orchestration on innovation performance (Li and Jia, 2018; Bittencourt, dos Santos, and Mignoni, 2021).

Responding to the preceding gaps and through quantitative research strategy, this study has developed and validated a conceptual model showing that the effect of technology orientation on innovation performance should be evaluated in conjunction with the availability and orchestration of strategic firm resources. To the researcher's knowledge, this is the first empirical study of small UK high-tech firms that examined the role of strategic firm resources as a possible mediator in the relationships between technology

orientation and innovation performance. It is a crucial addition to small high-tech firms and innovation literature by disentangling the role of firm resources and the use of resources (resource orchestration) in the innovation process. It also adds to the literature on small businesses in developed economies and, with these insights, offers theoretical and practical implications.

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Appendix A - Initial Results for CFA Analysis

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	122	1841.698	824	.000	2.235
Saturated model	946	.000	0		
Independence model	43	5966.643	903	.000	6.608

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.072	.644	.591	.561
Saturated model	.000	1.000		
Independence model	.286	.185	.146	.177

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.691	.662	.802	.780	.799
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.913	.631	.729
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	1017.698	897.122	1145.971
Saturated model	.000	.000	.000
Independence model	5063.643	4822.657	5311.247

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	13.155	7.269	6.408	8.186
Saturated model	.000	.000	.000	.000
Independence model	42.619	36.169	34.448	37.937

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.094	.088	.100	.000
Independence model	.200	.195	.205	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	2085.698	2197.531	2445.447	2567.447
Saturated model	1892.000	2759.167	4681.527	5627.527
Independence model	6052.643	6092.059	6179.439	6222.439

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	14.898	14.037	15.814	15.697
Saturated model	13.514	13.514	13.514	19.708
Independence model	43.233	41.512	45.002	43.515

HOELTER

Model	HOELTER	
	.05	.01
Default model	68	71
Independence model	23	24

FINAL CFA Analysis

Model Fit Summary

CMIN

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	107	715.324	421	.000	1.699
Saturated model	528	.000	0		
Independence model	32	4120.225	496	.000	8.307

RMR, GFI

Model	RMR	GFI	AGFI	PGFI
Default model	.065	.773	.715	.616
Saturated model	.000	1.000		
Independence model	.300	.226	.176	.212

Baseline Comparisons

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.826	.795	.920	.904	.919
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Parsimony-Adjusted Measures

Model	PRATIO	PNFI	PCFI
Default model	.849	.701	.780
Saturated model	.000	.000	.000
Independence model	1.000	.000	.000

NCP

Model	NCP	LO 90	HI 90
Default model	294.324	224.317	372.207
Saturated model	.000	.000	.000
Independence model	3624.225	3423.107	3832.679

FMIN

Model	FMIN	F0	LO 90	HI 90
Default model	5.109	2.102	1.602	2.659
Saturated model	.000	.000	.000	.000
Independence model	29.430	25.887	24.451	27.376

RMSEA

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.071	.062	.079	.000
Independence model	.228	.222	.235	.000

AIC

Model	AIC	BCC	BIC	CAIC
Default model	929.324	995.324	1244.842	1351.842
Saturated model	1056.000	1381.682	2612.945	3140.945
Independence model	4184.225	4203.963	4278.585	4310.585

ECVI

Model	ECVI	LO 90	HI 90	MECVI
Default model	6.638	6.138	7.194	7.109
Saturated model	7.543	7.543	7.543	9.869
Independence model	29.887	28.451	31.376	30.028

HOELTER

Model	HOELTER	
	.05	.01
Default model	92	97
Independence model	19	20

Appendix B – Ethical Approval

14th July 2022**Ethics Approval Application 2021/22****Researcher** – Akinbowale Aguda**Level of Research** – Category A**Director of Studies** Dr Gavin Smeilus**Title of Research** - Technology orientation and Innovation Performance: Evidence from UK small IT firms**Decision**

Your ethics application has been approved

Dear Akinbowale,

The Faculty Ethics Committee has approved your application

Please ensure that you are conversant with the latest guidelines on recruiting research participants and data security. See the Ethics Guidance web pages

<https://www.wlv.ac.uk/research/research-policies-procedures--guidelines/ethics-guidance/>

If you make any substantial changes to your research, you will have to complete a new request for ethical approval.

This letter only relates to ethical issues and has no bearing on other aspects of your research, such as methodology and theoretical framework.

Please do not hesitate to contact the relevant representative for your subject on Faculty Ethics Committee if you have any questions.

We wish you the very best with your research.

Yours Sincerely

Jason Jawando

On behalf of the Faculty Ethics Committee

Appendix C - Participant Information Sheet



Participant Information Sheet

Dear Sir /Ma

I am writing to invite you to participate in a questionnaire survey about the impact of technology orientation on innovation performance in small high-tech IT firms. The purpose of this research is to develop insights into technology orientation, firm resources, and innovation performance and formulate helpful advice. Your cooperation in completing this questionnaire would be greatly appreciated. Your company has been randomly selected from the FAME database (i.e., Financial Analysis Makes Easy), which is a financial database containing information on 300,000 major British companies from the Jordan Watch and Jordan Survey database. Your Participation in the survey is entirely voluntary, and you are free to withdraw from the survey at any time if you feel inconvenient. Your answers will be kept strictly confidential and private. All information will be reported for a group as a whole and your responses will not be linked to your name or your company. This survey will take about 15 minutes to complete. I genuinely appreciate your time in supplying this detailed information, which will be very useful to help us understand innovation in small IT firms. Your prompt response will contribute enormously towards the success of this survey. We truly appreciate your help and look forward to receiving your reply. This research project has been reviewed by the Faculty Research Ethics Committee at the University of Wolverhampton and has been given a favorable ethical opinion for conduct.

Thanks for your participation!

Contact Details

Akinbowale Aguda

[e-mail address redacted]

University of Wolverhampton Business School

Wulfruna Street, Wolverhampton

WV1 1LY

Supervisor contact details

Professor Yong Wang

Email:[redacted]

Appendix D- Questionnaire

Technology orientation and Innovation performance

Technology Orientation and Innovation Performance: Evidence from UK high-technology SMEs

The purpose of this research is to develop insights into technology orientation, firm resources, and innovation performance and formulate helpful advice. Your cooperation in completing this questionnaire would be greatly appreciated. Your Participation in the survey is entirely voluntary. Your answers will be kept strictly confidential and private. All information will be reported for a group as a whole and your responses will not be linked to your name or company. This survey will take about 15 minutes to complete. I genuinely appreciate your time in supplying this detailed information to the best of your ability, which will be very useful to help us understand innovation in high-technology SMEs. Your prompt response will contribute enormously towards the success of this research. I truly appreciate your help and look forward to receiving your reply.

Kind Regards

Akinbowale Aguda

Doctoral Researcher

University of Wolverhampton

[REDACTED]

Supervisor contact details:

Professor Yong Wang Email [REDACTED]

SECTION A: BUSINESS PROFILE

1. Name of the Company:

2. Year of incorporation:

3. Number of full-time employees as at date of survey:

4. Would you describe your company as a high-tech SME? *

Yes

No

(Definition of high-tech SME: High-tech SMEs are SMEs that are generally characterised as small and medium-sized firms with advanced knowledge and capabilities in technology, an educated workforce, and the ability to adapt quickly to fast-changing environments).

5. Please tick the business sector in which your firm majorly operates in

Business and domestic software development

Manufacture of computers and peripheral equipment

- Computer programming, consultancy, and related activities
- Telecommunications
- Information technology and computer service activities

Other

6. If you selected Other, please specify:

7. Please select the legal form of your firm by selecting the appropriate box only.

- Private limited company
- Public company
- Other

8. If you selected Other, please specify:

SECTION B: PERSONAL PROFILE

9. Please select your age band in (years) *

- 20-29
- 30-39
- 40-49
- 50-59
- 60+

10. Please tick your gender

- Male
- Female
- Transgender
- Non-Binary
- Prefer not to answer

11. Total working experience in (years)

- 0-5
 - 6-10
 - 11-15
 - 16-19
 - 20 or more
-

12. Please indicate your level of education

- A level or less
- Bachelor
- Masters
- PhD

-
- Others

13. If you selected Other, please specify:

14. What is your position in the firm?

- CEO/MD
- Chief Operating Officer
- Product Manager
- Chief Financial Officer
- IT Manager
- Operation Manager
- Chief Technology officer/Technical Director
- President/Vice President
- Other

15. If you selected Other, please specify:

SECTION C: TECHNOLOGY ORIENTATION

16. Please indicate your perceptions of your company's technology orientation by rating on a scale between 1 and 5, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. *

The policy of our firm has always been to consider the most up-to-date production technology available

- 1
- 2
- 3
- 4
- 5

We have a long tradition and a reputation in our industry of attempting to be first in trying new methods and equipment

- 1
- 2
- 3
- 4
- 5

We spend more than most firms in our industry on new product development

- 1
- 2
- 3
- 4
- 5

We devote additional resources to technological forecasting

- 1
- 2
- 3
- 4
- 5

SECTION D: Strategic Firm Resources (Financial Resources, Technological resources, Degree of Openness and Networking capability)

17. Please indicate your perceptions of the availability of resources in your organisation by rating on a scale between 1 and 5, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. *

(Financial Resources) We are satisfied with the financial capital available for our business operations

- 1
- 2
- 3
- 4
- 5

Our company has easy accesses to financial capital to support our operations

- 1
- 2
- 3
- 4
- 5

Our company has easy accesses to financial capital to support our operations

- 1
- 2
- 3
- 4
- 5

Our business operations are better financed than our key competitors

- 1
- 2
- 3
- 4
- 5

If we need more financial assistance for our business operations, we can easily obtain it

- 1
- 2
- 3
- 4
- 5

We can obtain financial resources at short notice to support business operations.

- 1
- 2

- 3
- 4
- 5

18. Please indicate your perceptions of the availability of resources in your organisation by rating on a scale between 1 and 5, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. - Duplicate *

(Technological resources) Our company has the technical and scientific knowledge and information relevant to the industry

- 1
- 2
- 3
- 4
- 5

Our company has new technical and scientific discoveries relevant to the industry

- 1
- 2
- 3
- 4
- 5

Our company has patented knowledge relevant to the industry

- 1
- 2
- 3
- 4
- 5

Our company has the technical and scientific personnel that make relevant discoveries

- 1
- 2
- 3
- 4
- 5

SECTION G: OPEN INNOVATION (Degree of Openness)

19. Does your firm engage in open innovation and have any co-operation arrangements on innovation activities with other firms? *

- Yes
- No

Open Innovation is defined as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation respectively”

20. Please rate your company's degree of openness with external partners in driving your innovation activities, where 1 denotes “not at all”, 2 denotes “Slightly”, 3 Denotes “Somewhat”, 4 Denotes “Moderately”, and 5 denotes “regularly”. *

To what degree has our firm cooperated with suppliers of equipment, materials, components, or software

- 1
- 2
- 3
- 4
- 5

To what degree has our firm cooperated with direct customers

- 1
- 2
- 3
- 4
- 5

To what degree has our firm cooperated with Indirect customers

- 1
- 2
- 3
- 4
- 5

To what degree has our firm cooperated with universities/commercial laboratories/R&D enterprises

- 1
- 2
- 3
- 4
- 5

To what degree has our firm cooperated with network partners

- 1
- 2

-
- 3
 - 4
 - 5

To what degree has our firm cooperated with intellectual property rights experts

- 1
- 2
- 3
- 4
- 5

SECTION F: NETWORKING CAPABILITY

21. Please indicate your perception of your company's networking capability by rating on a scale of 1 to 5 where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. *

We can explore and exploit the opportunities innovation networks contain

- 1
- 2
- 3
- 4
- 5

We have a strong ability to find, evaluate and select appropriate partners during the business process

- 1
- 2
- 3
- 4
- 5

We maintain and cooperate with a larger number of partners

- 1
- 2
- 3
- 4
- 5

We have had all kinds of partners, such as universities, research institutes, famous software companies, important

suppliers, customers, and so on

- 1
- 2
- 3
- 4
- 5

We have a strong ability to create and maintain dense ties with our partners

- 1
- 2
- 3
- 4
- 5

We have established a high number of ties with partners relative to the total possible number of ties

- 1
- 2
- 3
- 4
- 5

SECTION E: USE OF RESOURCES

22. Please indicate your perceptions on how resources are used in your organisation by rating on a scale of 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. *

Acquiring: Our organisation purchases tangible and intangible resources from strategic factor markets

- 1
- 2
- 3
- 4
- 5

Accumulating: Our organisation is committed to the internal development of tangible and intangible resources

- 1
- 2
- 3
- 4
- 5

Divesting: Our organisation sheds firm-controlled resources that do not add value to the firm in a way that is not harmful

- 1
- 2
- 3
- 4
- 5

23. Please indicate your perceptions on how resources are used in your organisation by rating on a scale of 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. *

Stabilizing: Our organisation makes minor incremental improvements in existing capabilities which is needed to maintain

our firm's current capabilities' level of proficiency

- 1
- 2
- 3
- 4
- 5

Enriching: Our organisation extends current capabilities which are needed to improve a firm's current capabilities' level of proficiency

- 1
- 2
- 3
- 4
- 5

Pioneering: Our organisation creates capabilities new to the firm by re-combining apparently unrelated resources in novel ways, and bundling new, complementary resources together

- 1
- 2
- 3
- 4
- 5

24. Please indicate your perceptions of the use of resources in your organisation by rating on a scale of 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. *

Mobilizing: Our organisation can integrate resources from various sources

- 1
- 2
- 3
- 4
- 5

Coordinating: Our organisation can mix resources from multiple internal and external sources as well as coordinate

resources integration with external partners

- 1
- 2
- 3
- 4
- 5

Deploying: Our organisation can implement resources in new product development as well as exploit and apply resources that reside within and outside the organisation into innovation activities

- 1
 - 2
 - 3
 - 4
 - 5
-

SECTION H: INNOVATION PERFORMANCE

25. Please indicate your perception of your company's innovation performance by rating on a scale of 1 to 5 where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree *

We often improve or revise existing products or services

- 1
- 2
- 3
- 4
- 5

We add new products or services to our existing ranges

- 1
- 2
- 3
- 4
- 5

We often reposition existing products or services

- 1
- 2
- 3
- 4
- 5

We often change the way we make products or deliver services

- 1
- 2
- 3
- 4
- 5

We introduce new or significantly improved processes for producing or supplying products (goods or services) which are

new to our industry

- 1
- 2
- 3
- 4
- 5

We develop products or services that better meet the needs of customers than any other product or service currently available

- 1
- 2
- 3
- 4
- 5

We introduce new products/services to an existing market

- 1
- 2
- 3
- 4
- 5

We introduce new products/services to a new market

- 1
- 2
- 3
- 4
- 5

We develop innovations that make our prevailing product/service lines obsolete

- 1
- 2
- 3
- 4
- 5

26. Please type in any comments you have in the box or you can contact me at

[REDACTED]

Appendix E: SIC Codes used in the study

Alphabetical Index to the UK Standard Industrial Classification of Economic Activities 2007 - UK SIC 2007		
1	SIC 2007	Activity
2	26702	Accessories for photographic equipment (manufacture)
3	26309	Aerial (domestic) (manufacture)
4	26309	Aerial (non-domestic) (manufacture)
5	49319	Aerial cable-ways operation
6	43210	Aerial erection (domestic)
7	43999	Aerial mast (self supporting) erection
8	26309	Aerial reflectors (manufacture)
9	28220	Aerial ropeway and cableway (manufacture)
10	26309	Aerial rotors (manufacture)
11	26309	Aerial signal splitters (manufacture)
12	71122	Aerial survey
13	30300	Aero engine manufacture (all types) (manufacture)
14	30300	Aero engine parts and sub-assemblies (manufacture)
15	90010	Aerobatic display
16	52230	Aerodrome
17	18130	Aerographing (manufacture)
18	30300	Aerospace equipment (manufacture)
19	21100	Antibiotics (manufacture)
20	32500	Artificial eye (manufacture)
21	01629	Artificial insemination activities on a fee or contract basis
22	86900	Artificial kidney unit
23	32500	Artificial limb (manufacture)
24	86900	Artificial limb and appliance centre
25	32500	Artificial parts for the heart (manufacture)

26	32500	Artificial respiration equipment (manufacture)
27	26701	Astronomical equipment (optical) (manufacture)
28	72190	Astronomy research and experimental development
29	26511	Biochemical analysers (electronic) (manufacture)
30	21200	Botanical products for pharmaceutical use (manufacture)
31	62012	Business and domestic software development
32	61200	Cellular network operations
33	26301	Cellular phones (manufacture)
34	26200	Central processing units for computers (manufacture)
35	26301	Communication devices using infrared signal (e.g. Remote controls) (manufacture)
36	26400	Compact disc players (manufacture)
37	26200	Computer (electronic) (manufacture)
38	26200	Computer (manufacture)
39	62020	Computer audit consultancy services
40	26800	Computer discs and tapes (unrecorded) (manufacture)
41	46140	Computer equipment
42	62030	Computer facilities management activities
43	62020	Computer hardware acceptance testing services
44	72190	Computer hardware research and experimental development
45	18203	Computer media reproduction (manufacture)
46	46620	Computer numerically controlled (CNC) machine tools
47	28410	Computer numerically controlled (CNC) metal cutting machines (manufacture)
48	26200	Computer peripheral equipment (manufacture)
49	17230	Computer print-out paper (manufacture)
50	26200	Computer projectors (video beamers) (manufacture)
51	62090	Computer related activities (other
52	85320	Computer repair training
53	62020	Computer site planning services
54	26200	Computer store (manufacture)

55	26200	Computer system (manufacture)
56	26200	Computer terminal unit (manufacture)
57	18130	Computer to plate CTP processing of plates for relief printing (manufacture)
58	18130	Computer to plate CTP processing of plates for relief stamping
59	46620	Computer-controlled machine tools
60	46640	Computer-controlled machinery for sewing and knitting machines
61	46640	Computer-controlled machinery for the textile industry
62	47410	Computers and non-customised software
63	46510	Computers and peripheral equipment
64	77330	Computing machinery and equipment rental and operating leasing
65	26200	Control units for computers (manufacture)
66	26120	Controllers interface cards (manufacture)
67	26200	Converter for computer (manufacture)
68	62012	Custom software development
69	18130	Data files preparation for multi-media printing on CD- ROM (manufacture)
70	18130	Data files preparation for multi-media printing on internet applications (manufacture)
71	18130	Data files preparation for multi-media printing on paper (manufacture)
72	61100	Data network management and support services (wired telecommunications)
73	26200	Data processing equipment (electronic (other than electronic calculators)) (manufacture)
74	28230	Data processing equipment (non-electronic) (manufacture)
75	61100	Data transmission (via cables, broadcasting, relay or satellite)
76	26301	Data transmission link line (manufacture)
77	62012	Database structure and content design
78	61100	Dedicated business telephone network services (wired telecommunications)
79	62011	Designing of structure and content of an interactive leisure and entertainment software database
80	62012	Designing of structure and content of business and domestic software databases
81	26200	Desktop computers (manufacture)

82	61900	Dial-up internet access provision
83	26200	Digital computer (manufacture)
84	18130	Digital imposition (manufacture)
85	26200	Digital machines (manufacture)
86	71122	Digital mapping activities
87	26511	Electronic GPS devices (manufacture)
88	26800	Floppy disk (manufacture)
89	26200	Hybrid computer (manufacture)
90	26110	Image converters and intensifiers (manufacture)
91	26702	Image projectors (manufacture)
92	18130	Image setting for letterpress processes (manufacture)
93	61100	Image transmission via cables, broadcasting, relay or satellite
94	60200	Image with sound internet broadcasting
95	26200	Information processing equipment
96	43210	Installation of computer network cabling and other telecommunications system cables
97	62090	Installation of personal computers and peripheral equipment
98	33200	Installation of telecommunications equipment
99	43210	Installation of telecommunications wiring systems
100	61200	Internet access providers (wireless telecommunications)
101	26200	Laptop computers (manufacture)
102	26200	Mainframe computers (manufacture)
103	26200	Micro-computers (manufacture)
104	26200	Mini-computers (manufacture)
105	26301	Mobile telephone (manufacture)
106	61200	Mobile telephone services
107	26120	Modem interface cards (manufacture)
108	26301	Modems (manufacture)
109	26200	Network interface (manufacture)
110	26120	Network interface cards (manufacture)

111	28220	Robots designed for lifting and handling in industry (manufacture)
112	28990	Robots for multiple industrial uses (manufacture)
113	26301	Routers for telecommunications (manufacture)
114	26200	Servers and network servers (manufacture)
115	46510	Software (non-customised)
116	58290	Software (ready-made) publishing
117	62090	Software disaster recovery services
118	62012	Software house
119	62090	Software installation services
120	62012	Software systems maintenance services
121	46520	Telecommunication instruments and apparatus
122	61100	Telecommunication network maintenance (wired telecommunications)
123	46520	Telecommunications equipment
124	47429	Telecommunications equipment other than mobile telephones
125	46520	Telecommunications machinery, equipment and materials for professional use
126	61300	Telecommunications satellite relay station
127	27320	Telecommunications wire (manufacture)
128	61100	Teleconferencing services (wired telecommunications)
129	61100	Telegraph communication
130	61100	Telephone communication (wired telecommunications)
131	61100	Telex service (wired telecommunications)
132	42220	Urban communication and power lines construction
133	61900	VOIP (voice over internet protocol) provision
134	61200	Wireless telecommunications activities