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Analysis of Business Model Innovation for Smart Cities Development

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Summary
Cities are the social, cultural, economic, technologic, and political hubs of the world, providing a wealth of goods and services to anyone who passes through them, Cities are the birthplace of innovation and play the role of a major catalyst in the advancements of the modern world. Currently over half the worlds population call a city home, and this is only expected to increase as we look into the future, Due to this, our cities must become 'smarter' to handle an ever-increasing demand, whilst continuing to develop and provide more and more benefits to the people who rely on cities. In order for this to happen, development must take place, however, this development must be carried out in a strategic manner, or it risks being unsuccessful and being a negative change that not only reduces the quality of lives for citizens but also has a heavy financial impact that causes loss for any stakeholders in a development scheme. To overcome this, business model canvas (BMC) can be used to weigh up potential benefits, or drawbacks and provide an insight into the way that the proposed business plan will perform, meaning when used properly there is less risk to stakeholders due to a greater degree of likelihood over performance. This added clarity is an essential part of what makes BMC's so popular and accelerates the processes of bringing about smart city development as any stakeholder will have a better idea of how their investment will pan out, whether this be financial, emotional, ambassadorial, or otherwise. This paper explores how a type of business model, the City Model Canvas (CMC) can be used to determine the impacts of smart city development in UK cities. This analysis is conducted through four case studies which review different aspects of a smart function to provide stakeholders with a picture of the smart functions' real-life application. Smart cities are the future of our world, and ensuring we develop them in the right ways will be vital to them serving their purpose, both for this generation and future generations.

Keywords: smart cities, digital, innovation, business model, and citizens.

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Introduction

Smart cities emerged as solutions to handle increasing urbanisation and increase the quality of living for all residents, this was done by harnessing physical infrastructures, Information Communication Technologies (ICT), knowledge resources and social infrastructure for economic regeneration, social cohesion, better city administration and infrastructure management (Ojo et al., 2015). The very first concepts of smart cities can be dated back to the early 1970s when Los Angeles, USA, launched an initiative known as the 'A Cluster Analysis

of Los Angeles' report. This primitive form of smart city application used computer databases, cluster analysis, and infrared aerial photography to gather data that helped to produce reports on neighbourhood demographics and housing quality and help direct resources to aid the urban population of the city such as by tackling poverty (Vallianatos, 2017). Following this, in 1994, Amsterdam, The Netherlands, launched an initiative known as 'De Digital Stad (DDS)', this was a free net initiative, that is recognised as one of the earliest attempts at incorporating ICT, specifically the internet into the daily lives of citizens, this was achieved by allowing residents to buy modems and 'dial in' to the service, as well as the social aspect of the internet, this was arguably the first attempt at 'smart governance' as through the DDS, 'the municipality of Amsterdam opened its entire administrative information system' (WAAG, 2014). As time went by and urbanisation continued to occur exponentially, it was clear among urban planners and technology firms that smart cities were the way of the future and in the mid 2000's two of the global tech giants, in IBM and Cisco, launched separate investments of $25m and $50m respectively, into the smart city sphere. These investments, along with others, were of huge importance and really set the direction for smart city development going forward and led to what we know modern smart cities to comprise of.

As time goes on and urban issues continue to gain prevalence, city governments increasingly require innovative arrangements to solve a variety of technical, physical, and social problems (Gil-Garcia et al., 2015). Smart cities help government resolve these issues by adding a layer of proactivity and enabling quick reactivity to problems. As stated by Arasteh et al., (2016) a smart city is equipped with different electronic elements employed by several applications, like street cameras for observation systems, sensors for transportation systems, etc. Almost all smart city functions can fall under the umbrella of being an application of the Internet Of Things (IoT), the IoT 'describes objects (or groups objects) with sensors, processing ability, software and other technologies that connect and exchange data with other devices and systems over the internet or other communications networks' (Gazis, 2021). It is this constant ability for interconnectivity that enables smart cities to work and function as successfully as they do today, just by examining the number of devices currently connected to the IoT we can see why this drive for big data and cloud computing is apparent.

Business models are an accelerant to the implementation of smart city functions and specifically helps companies that make cities smarter as they benefit from becoming more visible to cities around the globe with their newly developed or proven solutions. Business models are used when making key decisions about any matter, they aid in providing an overview of the benefits and drawbacks of any product and give all key stakeholders clarity over anticipated expenses. Simply speaking a business model is a key tool that allows entrepreneurs to explore a market (Doganova and Eyquem-Renault, 2009). Business models can take many forms as they can be tailored to suit a specific need, for a specific industry. As with all walks of life one must find a way of coming to a decision and find reasoning behind this, use of a business model canvas allows for this to occur.

Research Gap

As humanity continues to develop and aims to constantly improve the quality of life for all individuals' smart cities have been recognised as a significant way this can be achieved. "Smart cities are greener, safer, faster, and friendlier.'' (Mohanty et al., 2016). Smart cities emerged as a product of the significant improvements made in the software and hardware capabilities of ICT industry. Although smart cities come with a wide array of benefits there are significant barriers and complications that interfere with the implementation of them. The main barrier is the financial element, there has been estimates of a '$41trillion price tag' (Pattani, 2016) on the smart city market. There are many arguments made my industry personnel such as Puron-

Cid and Gil-Garcia (2022) that ask the question of whether or not this technology-intensive use that frequently comes with large investments in the ICT infrastructure necessary for smart city initiatives, is financially viable in the long term.

Smart city functions will also have many demands that traditional city functions do not have to face. As previously mentioned, smart cities are products of ICT technologies and therefore, many of the problems they face will be cyber related, such as hardware errors, glitches, poor design and cyber hacking. Because of this, the current business models utilise commonly are not specifically related to smart city development and there is space for improvement in this sphere. With this being said, smart city development is necessary for humanity to evolve and adapt to the future demands that we will be faced with, being able to answer these demands in a pro-active manner is vital and by using business models when making key decisions regarding smart city functions everybody should have more clarity on the pros and cons of their decisions. However, it is recognised that in the industry the amount of literature available regarding business models specifically for use in smart city development is limited and as such, the research gap of exploring how business models can be improved on and innovated to factor in smart city models and become smart city specific as to optimise the effectiveness and clarity available to key stakeholders in the decision-making processes.

Research Methodology

To gain a holistic understanding of the use of business models in smart city development it is important to complete case studies relating to how a business model would be used in the development of current smart city applications, factoring in all aspects of a business model and understanding the value that will be created. To do this, use of a current, common, business model canvas was used, with findings from a literature review implemented into it to see how use of the business model would provide value ton stakeholders from a smart city perspective.

A systematic review of published literature was undertaken to ensure relevance to the core topic and to specifically aid my requirements for completing the case studies. The method used to enhance my review was the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA, see Figure 1).

The early stages of the systematic review were done by critically analysing a wide range of scholarly articles, peer-reviewed papers published in academic journals and government reports. These pieces of literature were curated by searching the online database of the University of Wolverhampton's library, this library consists of reports from Science Direct, ProQuest, Google Scholar, and the university itself. The key words used to specify search through the aforementioned databases were, "smart cities'' OR ''UK'' OR "digital'' OR "innovation'' OR "business model'' OR "business''. There were several other relevant pieces of literature from other databases that were used to supplement the findings from initial review and provided concrete findings that enhanced the quality of literature review. Some of these were from the likes of; UK Government, IT Pro, CNBC, and WAAG.

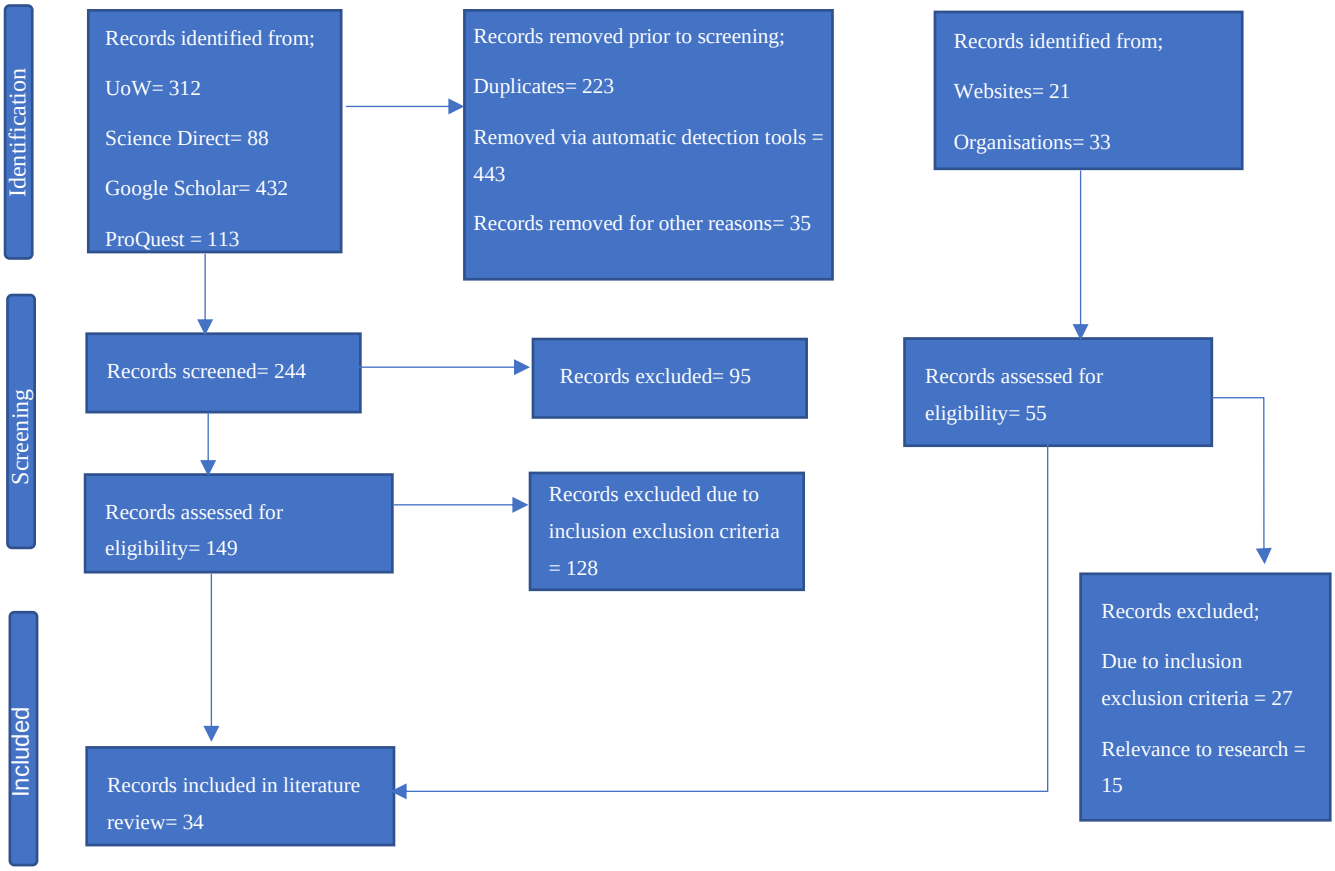
To further increase relevance and ensure the exclusion of irrelevant literature or biased information, did not include, articles published prior to 2000, unverified web papers, unpublished papers, dissertations, articles not written in English and articles not focused on UK projects. Table 1 shows an inclusion/exclusion criteria used in this study.

Inclusion Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
-Published between 2000-2023 -Written in full English -Scholarly articles, peer-reviewed journals, Government reports	-Published prior to 2000 -Unavailable in English -Unpublished papers -Unverified web papers -Duplicate papers -Dissertations

Table 1– Exclusion/Inclusion criteria

Figure 1: The PRISMA screening process that was used throughout the search for relevant literature



Findings

The main purpose of smart city development is to create an urban area that optimises all the cities' functions, promoting innovation and economic growth within the city, this is done with the goal of creating a higher quality of life for all residents and businesses that operate in the city. Smart cities emerged as a solution to address the challenges that arise with exponential growth of urbanization and population' (Silva et al., 2018) because of this, smart cities adopt strategies 'through a combination of innovations and new technologies (Chawviang and

Kiattisin, 2022), such as the IoT, Artificial Intelligence (AI) and data collection and analysis systems. Despite the righteous ambitions of smart city development, there is significant ethical considerations to take into consideration when creating one, this is because smart cities rely heavily on collecting and analysing data to create autonomous, or semi-autonomous solutions for problems that occur, this data is often personal to each individual, such as CCTV monitoring and GPS locator systems. This can create significant problems for advocates of smart city development, and acts as a barrier to progression. However, with more and more smart cities being developed in the UK, it is clear that these issues are being overcome and we are believing in smart city policies to help deal with the consistently growing rates of urbanisation.

Every smart city has fundamental elements that enable it to gain smart city status, and function as a fully smart city. These key fundamentals are: smart infrastructure, smart buildings, smart transportation, smart energy, smart healthcare, smart governance and smart education (Quasim et al., 2020). Further to this, every development in a city needs to be evaluated to specifically define the purposes for it, who it will benefit and how it will benefit them. However, part of this evaluation process should also look at some of the problems with implementing a devlopment and arguments against it, for this reason business model canvases are used, they enable the user to develop innovative business models by redesigning the contents of any one of its nine blocks to uncover new business opportunities and turn customers' needs into profitable activities (Giourka et al., 2019). One of these business model canvases is the City Model Canvas (CMC). This canvas is a framework for private firms that assesses a traditional BMC alongside a second canvas centred on environmental value and a third canvas focused on social value (Timeus et al., 2020). Viewing how this business model is implemented in four case studies of current UK smart city fundamental development strategies can show the pros and cons of them.

Limitations of the City Model Canvas (CMC)

As previously mentioned the city model canvas is an adaptation of a traditional business model canvas, however, although modernised in some components it is still not the ideal tool for aiding smart city development. There are numerous aspects of the city model canvas which limits its ability to create value for potential stakeholders these limitations often mean components that are essential or highly beneficial are missed at the initial stages of development, which one could expect to be the most common stage where of adoption of business model canvases occur.

- **Lack of Stakeholder Analysis**

Smart city initiatives often involve many different stakeholders, they can include government agencies, private companies, and community-led collectives. Business models do not allow for an integrated approach to stakeholder analysis, which is crucial for understanding the diverse interests, needs, and relationships that will exist smart city ecosystems, requiring a diligent method to enhance and maximise impact. Ignoring stakeholder dynamics can lead to incomplete or unrealistic business model designs.

- **Long Term Impacts**

Smart city projects often aim for prolonged opportunity for societal and environmental advancement instead of the traditional profit-centred targets for development of a business model. This explicit focus on the sustainability of the 'triple bottom-line' is something that is not captured in the CMC rather, it captures the goal of an immediate benefits. The BMC heavily emphasises revenue streams, cost structures, and value propositions, which may not adequately

capture the requirement for the broader long-term social, environmental, and economic impacts associated with smart city development.

- **Regulatory and Policy Considerations**

Smart city schemes, like any other type of development will need to operate within regulatory frameworks and policies set by the relevant government or local authorities. The CMC does not provide sufficient scope for the need to address potential legal and regulatory hurdles, which can significantly impact the implementation and feasibility of the final smart city business model. Analysing and adapting to the legal and policy requirements will mean additional considerations beyond the scope of the CMC are needed.

- **Technological Barriers/Opportunities**

Smart cities rely heavily on technology, such as Internet of Things (IoT) devices, data analytics, and artificial intelligence (AI). However, with this comes a host of barriers which will limit the value created by the proposal, as well as opportunities which will maximise the value created by the proposal in both the immediate and future. The CMC does not have enough scope to address potential technological requirements and any associated risks, challenges, and opportunities. Understanding the technological infrastructure and potential vulnerabilities is crucial for smart city business models, which the CMC does not allow for full exploration.

Case Study 1: Smart Infrastructure - Newcastle

Smart infrastructure is vital component of any smart city. Smart infrastructure relates to the ability of a system to collect data and produce or follow processes that can act in response to that data. As society moves deeper into the twenty-first century, the societal demand on infrastructure assets is growing rapidly, with high expectations in terms of productivity and service delivery (Ogie et al., 2017), due to this optimisation of smart infrastructure can be seen as a solution to the problem. An example of a city in the UK that has looked to benefit from smart infrastructure is Newcastle. It was a major city of the industrial revolution and currently has 800,000 residents. Like many UK cities, Newcastle requires post-industrial regeneration and for this reason a scheme known as the Newcastle Urban Observatory Project was launched. Much of the work done to implement smart infrastructure in Newcastle was related to application based on the IoT, a system that connects devices to the internet and enables action to be taken autonomously based on data collection and analysis. The final report on the implementation of smarter infrastructure in Newcastle speaks of being able to support city planning, management and social awareness and develop new methods of appraisal for future infrastructure or policy interventions; and instrumental in informing and validating policy decisions, as hypothesised, but also non-policy interventions such as tuning of algorithms for traffic signals and nudge-based approaches to alleviating dense crowds during COVID-19 (James et al., 2022). Thus, showing just how smart infrastructure should be used to improve the quality of life for citizens. Based on thorough analysis of literature, a business model canvas for smart infrastructure in Newcastle is developed (Figure 2).

<table>
<tr><td colspan="5">Mission Statement: Smart Infrastructure</td></tr>
<tr><td rowspan="2">Key Partnerships:
-Citizens
-Local Council
-Sensor developing companies
-Data analytics companies
-Data collection companies
-App/Website development companies</td><td>Key activities:
- Use of infrastructure services
- Collection and analysis of data
-Installation of data collection devices (cameras, sensors)
-Connection of infrastructure services to the IoT
-Management of infrastructure services
-Constant review of efficiency of services
-Constant updating of services and technology</td><td rowspan="2">Value proposition:
-More efficiency and productivity across all infrastructure services in the city, leading to less maintenance cost and less environmental impact</td><td>Buy-in and Support:
-Citizens inform smart infrastructure of issues and the system can then implement solutions
-Smart infrastructure uses data collection analysis, using sensor, cameras etc to make decisions.</td><td rowspan="2">Beneficiaries:
-Citizens
-Local Council
- Companies that rely on infrastructure use</td></tr>
<tr><td>Key infrastructure, resources, and key regulatory framework:
-Employees
-Data collection devices
-Data analytics software
-IoT enabled infrastructure network
-IoT enabled infrastructure buildings
-Mobile networks
-Internet access
-Mobile/Internet applications</td><td>Deployment:
-Media news
-Social media advertisement
-Public conferences
-Live interviews on platforms such as TV and social media
-Mobile applications
-School assemblies</td></tr>
<tr><td colspan="2">Budget cost structure:
-Employee salaries
-Installation of data collection devices
-Possible construction of facilities to handle the data
-Paying private companies to develop software and apps to handle the data
-IoT infrastructure service management costs
-Infrastructure management and maintenance costs
-Infrastructure upgrade costs (e.g., installing a new operating system)</td><td colspan="3">Revenue streams:
-City council can use tax rates to pay for implementation of smart infrastructure.
-Savings made as not as many employees required due to autonomous nature of smart infrastructure
-Savings made as infrastructure system will be much more efficient and productive.</td></tr>
<tr><td colspan="2">Environmental cost:
-Increased energy and electrical consumption to power smart infrastructure services and networks.</td><td colspan="3">Environmental Benefits:
-Smart infrastructure can be adapted to prioritise reduction of environmental impact
-Can be used to notice new environmental impacts that wouldn’t have been noticed otherwise (e.g., carbon emission monitors)
-Creation of more environmentally friendly urban environment</td></tr>
<tr><td colspan="2">Social risks:
-Elderly residents may prefer traditional infrastructure methods
-Arguments against ethical implementation of data collection and analytics
-Privacy issues</td><td colspan="3">Social benefits:
- Higher service quality leading to higher quality of life
-Less environmental impact meaning increased urban healthiness
-More efficient city in many departments (e.g., quicker waste management)
-Increased happiness within the city.
-City will attract other businesses due to the efficiency and accessibility of the infrastructure system.</td></tr>
</table>

Figure 2: City Model Canvas for Smart Infrastructure in Newcastle

As can be seen from the Figure 1, business model canvas created the number of benefits that will be produced as result of smart infrastructure development in Newcastle are vast. The beneficiaries will not only be environmental but also the residents, local businesses and future residents. This focus on future residents must be considered due to the current trends of urbanisation, and integration of smart infrastructure will aid in making Newcastle a much more attractive location for people to move to. On the other hand, improving current, traditional

infrastructure and making it smart is not a cheap task and requires a significant degree of funding, as well as time to get all the services up to full working speed and connect with the residents that require them. Overall, Figure 1 provides proof that smart infrastructure in Newcastle is a necessary step that will boost the local economy and bring about many improvements to life in the city.

Case Study 2: Smart Transportation - Birmingham

'Smart' in the transport sector can refer to new propulsion (e.g., electricity), new vehicle controls (e.g., Intelligent Transport System), new business models (e.g., mobility-as a –service' model), new regulatory, and new transport planning and policies (Chen and Silva, 2021). Smart transportation is fundamental to any smart city development. Smart transportation will boost the city in many aspects, from efficiency and accessibility to environmental sustainability. Transport currently accounts for around a quarter of the UK's greenhouse gas emissions (Hillmansen, 2020). Birmingham is currently the second-most populated city in the UK, with over 1 million inhabitants. Many of these residents will need to undertake some form of transport to live their daily lives, therefore, installing smart transportation networks would significantly benefit the lives of these individuals by being safer, faster, more accessible, and more affordable.

Birmingham is currently running schemes and trials with electric vehicles and even introduced 20 hydrogen double decker buses to its fleet, with hopes its entire bus fleet will be zero-emission by 2030 (Seymour, 2020). This a huge step for the city as the percentage of transit riders in West Midlands who ride public transit, including Light Rail, Train and Bus for more than 2 hours every day is 45% (Moovit, 2022). Additionally, with services such as HS2 running directly through the city, it has become a hub for smart transportation development and in 2022 revealed a £227m metro expansion plan. In addition to this, Birmingham City Council (BCC) is investing heavily in electric vehicle infrastructure in the city with the aim of reducing emissions. Currently, transport accounts for one third of Birmingham's CO_2 emissions of which 95% derives from road transport (Zaffar, 2021).

Because of this the BCC has created a 12-year electric vehicle strategy, where 3,000 electric vehicle charge-points will be rolled-out across Birmingham to reduce city emissions by 50% in 2030 compared to 2020 levels (BCC, 2021). Based on thorough analysis of literature, a business model canvas for smart transportation in Birmingham is developed (Figure 3).

Mission Statement: Smart Transport				
Key Partnerships: -City council -National government -Transport managers -Transport company owners -Citizens -Designing companies - Infrastructure managers -Maintenance managers	**Key activities:** -Networks planning -Asset management -Data analytic and collection services -Review processes -Maintain the systems put in place -Ensure the services are carrying out their value proposition	**Value proposition:** -Transport systems that have less financial cost and are more affordable for all - Transport systems that work with better efficiency and are more reliable - Reduction of environmental impact of the transport system -Improve residents' quality of life	**Buy-in and Support:** -Local council would receive funding from the government to invest in new methods of smart transport -Users would use the new smart services, such as public transport or electric vehicle charging points -All individuals that use these services would be directly contributing to	**Beneficiaries:** -Citizens -Organizations providing the transport systems -Electric vehicle manufacturers -Electric vehicle charging point providers

<table>
<tr><td rowspan="2">-Asset managers
-Marketing companies
-EV companies
-EV charging companies</td><td></td><td rowspan="2"></td><td>improved environmental impact</td><td rowspan="2"></td></tr>
<tr><td>Key infrastructure, resources, and key regulatory framework:
-Employees of the transport providers
-Other transport service users who may be inconvenienced
-Data analytic and collection platforms
-Asset managers
-Maintenance managers</td><td>Deployment:
-Newspapers
-Emails
-Workshops
-Conferences
-Social media advertisements
- Leaflets through residents’ doors
-Word of mouth
-Other promotional methods</td></tr>
<tr><td colspan="3">Budget cost structure:
-Employee salaries
-Operational costs
-Initial project costs, e.g. construction of new railways
-Costs of expanding infrastructure
-Financial incentives for electric vehicle users</td><td colspan="2">Revenue streams:
- Collected revenue from payment for residents to use these services, e.g., bus fares.
-Less operational maintenance costs once installed.</td></tr>
<tr><td colspan="3">Environmental cost:
-Energy consumption
-Initially high emissions during construction phases</td><td colspan="2">Environmental Benefits:
-Less energy consumption leading to a reduced environmental impact once fully operational
-Less greenhouse gas creation
-Higher air quality, noise quality and light quality across the city.</td></tr>
<tr><td colspan="3">Social risks:
-Could lead to operational issues whilst new system is under construction, e.g., road closures to allow for a new tramline to be installed.</td><td colspan="2">Social benefits:
-Faster, more efficient, more reliable, and more accessible service once complete and operational.
-Job creation in the city</td></tr>
</table>

Figure 3: City Model Canvas for Smart Transportation in Birmingham

In summary, for smart transportation Figure 3 shows what steps are required for this function to have its maximum effect. It also shows that Birmingham is a place that requires smart transportation due to a variety of reasons, also, the benefits that development of smart transportation would have on both the residents of the city and the environment. Having smart transportation systems will mean more reliable and efficient public transport services and much more environmentally friendly personal/private modes of transport, such as electric vehicles. It also shows that investment into the sector is of paramount importance and will require a good degree of funding and planning, this has been a barrier in the past but is one that can be overcome.

Case Study 3: Smart Governance – Glasgow

Smart Governance is collaboration in which the role of governance is to enhance the communication and collaboration among different actors and encourage improvement and new innovations (Perätalo et al., 2022). There are three main components of smart governance that will result in successful implementation of it and enable it to thrive, these are societal goals,

collaboration, and technologies. Societal goals refer to the aims of an individual or collective that will benefit the wider public and not just that individual or collective, such as the goals of the mayor of Glasgow. Collaboration refers to the engagement of diverse actors whose visions and resources are necessary to define and implement collective goals (Camboim et al., 2019), these actors would be individuals such as, government officials, community leaders or even just city residents. Technologies relates to any technological elements of the city that would improve the governance of the city, such as electronic polling systems that would make it much simpler for residents to vote. Smart Governance is a fundamental function for any smart city, because of this it can be used to better govern the people of a city and promote a better quality of life for those in the city. Glasgow, a major city of almost 1.7million residents, is one that employed this fundamental function to boost efficiency and make their city smarter, as part of the additional £24m in government funding to boost science and technology (Mitra-Thakur, 2013). One reason Glasgow opted for smart governance is because a significant number of citizens live in deprived areas (Leleux and Webster, 2018). Furthermore, the city wanted to regenerate the city, to reflect modern ways of living and make it suitable for the ever-changing demands of urban areas, such as environmental and urbanisation issues. They did this by developing a scheme called the 'Future City Glasgow Programme' and receiving £24m in funding as part of the 2-year TSB grant. smart governance in Glasgow.

<table>
<tr><td colspan="5">Mission Statement: Smart Governance</td></tr>
<tr><td rowspan="2">Key Partnerships:
-Local council
- Key members of communities
- Businesspeople
-National government
-App/Website creation companies
-IoT infrastructure management</td><td>Key activities:
-Taking quick action when problems arise
- Listening to arguments for and against action plans
-Holding meetings
- Coming to an agreed decision.</td><td rowspan="2">Value proposition:
-Better governance for all
-More efficient decision making from government
-Solutions to problems found more effectively
-Higher quality of life for citizens
-More accountability for decisions.</td><td>Buy-in and Support:
-Residents can report issues and contact governance personally through apps and websites.
- Better relationships between government and the residents of the city
- Residents of the city more involved in decision-making</td><td rowspan="2">Beneficiaries:
-Citizens
-Residents can report issues and contact governance personally through apps and websites.</td></tr>
<tr><td>Key infrastructure, resources, and key regulatory framework:
-Citizens
-Politicians
-Local businesspeople
-Mobile apps
-Data collection tools
-IoT infrastructure</td><td>Deployment:
-Conferences
-Meetings
-Question and Answer sessions
-Livestreams
-Interviews
-Newspapers
-Magazines
-Emails
-Social media
-Digital news outlets (TV, Radio)</td></tr>
<tr><td colspan="2">Budget cost structure:
- Cost of implementing action required to solve issue may be expensive
-Costs to develop apps and websites
-Salaries
-Costs to promote new smart governance initiatives</td><td colspan="3">Revenue streams:
-The local council would collect taxes to pay the politicians or individuals that work on their behalf and formulate the strategies to put action in place.</td></tr>
<tr><td colspan="2">Environmental cost:
-None</td><td colspan="3">Environmental Benefits:
-Environmental risks would be sorted out quickly, meaning less of an impact environmentally.</td></tr>
<tr><td colspan="2">Social risks:
-None</td><td colspan="3">Social benefits:
-Residents feel more in control of decision-making that affects them
-Higher quality of life as problems are sorted out quicker
-More social and relational capital between council management and residents of the city.
-Improved job creation in the city
-More equality within the city.</td></tr>
</table>

Figure 4 – City Model Canvas for Smart Governance in Glasgow

Based on thorough analysis of literature, a business model canvas for smart governance in Glasgow is developed (Figure 4). Glasgow is a city in the UK that prioritised introducing smart governance in their city. Figure 3 shows that smart governance in the city will improve the quality of life for all those in the city, from residents to politicians. Smart governance would enable the city to make meaningful decisions that would solve issues that the people of the city are facing, these decisions would be made quicker and with more certainty than ever before. This is an important function of a smart city as it will boost the economy and make the city more sustainable on a societal and relational level. When Glasgow developed smart governance and employed it within the city it created profits of close to £150m (Tute, 2017) from an initial £24m investment, and significantly improved the quality of life for all. This is proof that

business model canvas accurately forecasts the effects of smart governance in Glasgow and that by prioritising this function a city will become more sustainable, smarter and a safer place.

Case Study 4: Smart Waste Management - Edinburgh

Edinburgh is the capital city of Scotland and is home to over 500,000 residents and almost 250,000 households, making it the 7th largest city in the UK. In October 2021, City of Edinburgh Council (CEC) published a plan entitled the 'Digital and Smart City Strategy'. This strategy focuses on how the city will use the IoT to enable 'data and cloud-powered technology to connect systems in a digital age to provide even more accessible, secure, and efficient services for residents (Millman, 2022). One of the main areas this strategy looks to optimise is the waste management system in the city. Smart waste management covers all the activities necessary for monitoring the waste generated in a city, from its beginning, when citizens produce their waste, through collection, transportation, and arrival at its final accommodation (Pardini et al., 2020). Traditionally, waste disposal trucks in the city follow a route that has been calculated to work for maximum efficiency in terms of distance travelled, this made sense as it meant it cost less to clear the bins of residents in the city, but this did not factor in if they were collecting empty bins or full bins, therefore, to optimise the waste management system, the waste disposal trucks should be optimised for maximum waste disposal. Additionally, Edinburgh is a city that has a bigger tourist attraction at time likes Christmas, this means more of a demand for waste disposal at these times, this presents a dynamic issue as there will be differing amounts of waste to always collect. Solving this issue would have an instant impact on urban healthiness and environnemnal impact, however, it requires a constantly adapting system that can reroute disposal trucks according to what data is collected.

The way the city will allow for this to happen is by installing IoT sensors to over 11,000 bins. These sensors will be connected to the 'LoRaWaN' network, from here data will be collected, such as how full the bins are, and sent to 'SensorInsights360', a data collection and analysis network. From here the data will be interpreted and uploaded autonomously into an internal system ran by the council which the bin workers will have access to, meaning the relevant teams can react to the data dynamically and take the necessary action.

<table>
<tr><td colspan="5">Mission Statement: Smart Waste Management</td></tr>
<tr>
<td rowspan="2">Key Partnerships:
-Local council
-National government
-Waste management companies
-Waste disposal companies
-Residents</td>
<td>Key activities:
-Waste collection
-Installation of sensors
-Data collection, processing, and analysis
-Management of the smart waste management system.</td>
<td rowspan="2">Value proposition:
- More efficient and effective waste management for the residents, meaning lower economic cost for council and less environmental impact as waste will not be left for too long or missed out.</td>
<td>Buy-in and Support:
-Residents puts their waste into the collection bins
-Waste disposal workers collect bins based on fullness</td>
<td rowspan="2">Beneficiaries:
-Residents
-Waste management companies
-Recycling companies
- Local Council</td>
</tr>
<tr>
<td>Key infrastructure, resources, and key regulatory framework:
-Employees
-Trucks and waste collection bins
-Sensors
-IoT infrastructure (LoRaWan network)</td>
<td>Deployment:
-Social Media advertisements
-Other digital news outlets (TV, Radio)
-Newspapers
-Local news boards
-Mobile app
-Email
-Door-to-door letters</td>
</tr>
</table>

	- Waste management system (Recycling plant), (Landfill)			
Budget cost structure: -Salaries -IoT infrastructure management cost Installation of sensors and set up of infrastructure cost -Cost of running waste disposal trucks -Cost of running waste management plants -Cost of promoting smart waste management services.		**Revenue streams:** -City can use taxes collected to pay for service improvements -Can sell waste to be recycled		
Environmental cost: -Increased electrical and energy consumption to power IoT infrastructure -Possibly more emissions from waste disposal vehicles as they will be optimised for waste disposal instead of distance driven.		**Environmental Benefits:** -Better ecosystem in the city -Cleaner air in the city and less air pollution -Waste being disposed of in the right way (e.g., not being disposed in rivers, lakes etc...)		
Social risks: -None		**Social benefits:** -Lower service cost can allow for cost reduction -Job creation -Greater quality of life -Less health problems in the city due to cleaner city -Improved tourism due to cleaner streets.		

Figure 5: City Model Canvas for Smart Waste Management in Edinburgh

Based on thorough analysis of literature, a business model canvas for Smart Waste Management in Edinburgh is developed (Figure 5). Smart waste management has been introduced in Edinburgh as a system to increase efficiency, drive innovation and make life simpler for all residents. Development of this function will lead to better environmental impact and a more cost-effective waste management system. The city strategy to deal with waste issues relates to using the IoT to connect sensors that can send alerts when a bin is full and should be disposed of, thus meaning bins are not left full for long and there is a constant cycle that means the fullest bins are emptied up when they need to be. This function will not be as expensive as other functions to implement and can be fully rolled out in a quick amount of time. It will also improve numerous aspects of quality of life in the city, it will increase public healthiness and promote a clean and hygienic culture in the city.

Conclusions and recommendations

The review of literature revealed that using a city business model canvas will benefit the key partnerships that are looking to implement smart city functions. It does this by providing a wide overview of the benefits and drawbacks that will come with application. This allows the stakeholders to make informed and calculated decisions. Using the city model canvas, it has clear questions that force the stakeholders to delve deep into the reasoning behind their plans and provides a clear structure that gives clarity to the whole process, making it easier for all who are included in the decision-making process to understand the reasons for and against. Along with this, it is clear that using the CMC, it provide with some common benefits and drawbacks to smart cities. These are that introducing new functions will often be expensive and require a period of time to allow the residents to become comfortable with the new systems, another clear drawback is that the city council must be willing to implement the function, as without this it will be difficult to pass the relevant legislations that will make application viable. The positives are, however, hugely advantageous to any city and thus, make it worthwhile.

These common positives are that smart city functions will make cities, safer and more accessible to all, they will boost the cities economy and improve the quality of life for all citizens. It is recommended that for successful application of smart city elements, many different parties will have to collaborate and work together with the overall aim of improving the lives of the residents of the city. Therefore, it is recommended all parties that may be looking at utilising smart city functions in their city, to use the CMC as it will provide them with an excellent overview of the impact their proposed plans will have and will give all stakeholders clarity when making key decisions in relation to the implementation. Also, need to work with innovative tech companies to enable quick and efficient methods of transferring large amounts of data over secure networks, such as using the IoT. As well as this, working with companies that can store this data securely and analyse it to implement action is vital, as this is the fundamental processes of how smart city functions are applied in real life scenarios, there must be a stable initial infrastructure to allow for this to occur and the key partnerships must be willing to constantly invest in the function, to ensure it is kept up to date and in good working order.

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