Accepted paper: Journal of Business Research, 12 September 2021

Internet of Things: Aspiration, Implementation and Contribution?

Eleanor. E. Cranmer
(*Corresponding Author)
e.cranmer@mmu.ac.uk

Department of Operations, Technology, Events and Hospitality Management, Manchester Metropolitan University

Faculty of Business and Law, All Saints Campus, Manchester Metropolitan University, Manchester, M15 6BH

M. Papalexi

m.papalexi@mmu.ac.uk

Department of Operations, Technology, Events and Hospitality Management, Manchester Metropolitan University

M. Claudia tom Dieck

C.tom-dieck@mmu.ac.uk

Department of Operations, Technology, Events and Hospitality Management, Manchester Metropolitan University

D. Bamford

d.bamford@mmu.ac.uk

Department of Operations, Technology, Events and Hospitality Management, Manchester Metropolitan University

Internet of Things: Aspiration, Implementation and Contribution

Abstract
The Internet of Things (IoT) technologies offer unique opportunities for organisations to improve their performance, innovativeness and as a result pursue competitive advantages. However, organisations are uncertain how to adopt IoT to exploit its potential. This study explores emerging issues and future horizons in the IoT business model context, identifying factors that influence and hinder organisation's ability to implement IoT. A survey with 201 respondents revealed a number of drivers and barriers to IoT implementation. These findings informed the development of the Aspiration, Implementation and Contribution (AIC) business model framework that offers guidance to organisations about how to adopt IoT in order to create value. Findings provide novel theoretical insight into the barriers and drivers influencing the implementation of IoT technologies. The development of the AIC business model will help standardise the realisation of value and implementation of IoT.

Key words: *Internet of Things, Business Models, Value, Innovation*

1. Introduction

The Internet of Things (IoT) has been identified as one of the most important emerging technologies because of its potential to improve lives, save time and money (Lee & Lee, 2015; Whitemore et al., 2015). IoT is considered an ecosystem whereby a number of digitally embedded devices (e.g. things) communicate through the internet (Sharma et al., 2020). Examples of IoT within the business and industry context include IoT data analytics, sensor-managed inventory, intelligent retail technologies, or sensor driven climate control to name a few (HPE, 2021). IoT connects people with physical objects, such as vehicles, home appliances, and smartphones enabling them to communicate with each other, sharing data to produce intelligent services and improve quality of life (Abbate et al., 2019). Technological advances, miniaturisation and decreased costs of supporting technologies (e.g. artificial intelligence, cloud computing, bitcoin) have increased the relevance of IoT for both industry and end-users (Bagloee et al., 2019; Lombardi et al., 2019; Le et al., 2019; Scholz-Reiter, 2018; Uckelmann et al., 2018). Many industries, such as, retail, manufacturing and healthcare have begun to adopt IoT to exploit its ability to collect and process data, to facilitate real-time informed decision-making (Le et al., 2019; Lee & Lee, 2015). IoT shows potential to reshape entire industries, change work processes, create new economic benefits, save time, money and ultimately improve lives (Lee & Lee, 2015; Porter & Heppelman, 2014; Whitemore et al., 2015).

Despite such perceived benefits, investigations into how IoT technologies can be implemented by organisations to enhance their performance and create value are scarce. Many still consider IoT a novelty, as barriers such as high costs, lack of knowledge and unsuitable infrastructures delay widespread adoption (Saarikko et al., 2017). Prior to the effective adoption of IoT, issues of privacy, reliability, novelty, costs and network instability must be addressed (Saarikko et al., 2017; Sharma et al., 2020). It is claimed that organisations feel obliged to integrate IoT products and services to mirror competitors, and it is thus misused as a buzz word, rather than creating value or exploiting new opportunities (Noronha et al., 2014; Saarikko et al., 2017; Uckelmann et al., 2018). Therefore, important questions emerge regarding the creation and capture of value, and how businesses should best integrate IoT into their strategy. As highlighted by Noronha et al. (2014, p. 5) “connecting things is but a means to an end”. Indeed, there is a gap in research, where academics and practitioners debate how IoT technologies can create value (Bilgeri & Wortmann, 2017; Krotov, 2017; Scholz-Reier, 2018). In particular, the absence of an IoT business model is cited as one of the main reasons for delayed adoption (Haaker et al., 2021; Krotov, 2017; Le et al., 2019; Turber et al., 2014). This highlights a need to further explore how IoT value is created and captured. Haaker et al. (2021, p. 135) confirmed that there is a general lack of theoretical research into IoT as "to date, literature has largely focused on the technological aspects of IoT".

Business models are widely accepted tools to explain the logic of an organisation, the way it operates, and crucially, how it creates and captures value (Baden-Fuller & Morgan, 2010). A number of scholars have identified the need to develop an IoT specific business model, which considers the unique context and specific characteristics of IoT, to help organisations capitalise on opportunities, create and capture IoT value (Abbate et al., 2019; Krotov, 2017; Le et al., 2019). However, a practical and effective IoT business model is yet to emerge. According to Haaker et al. (2021, p. 135) “developing viable BMs for IoT-based processes and propositions” has received little attention, however “establishing and developing a robust BM that will build sustainable IoT business success”. There is, therefore, a need to explore the phenomenon of IoT in order to help organisations better understand IoT technology potential and crucially how value is created through implementation. Understanding these factors and developing a framework to assist organisations in the realisation of IoT value offers a significant contribution to knowledge. To bridge this gap, by addressing the following research questions, this study aims to provide theoretical insight into implementation of IoT technologies, to develop a framework that can standardise the realisation of value and implementation of IoT.

RQ1: What factors influence and hinder organisations ability to implement IoT?

RQ2: What are the key criteria of an IoT business model?

The theoretical contributions of this study are threefold. First, we develop a business model for IoT incorporating aspirations, implementation and contribution in order to provide academia and industry with a framework for successful IoT implementation. Second, we advance previous research that to date has largely focused on technical IoT implementation by empirically exploring key business model criteria and challenges. Third, we address the current lack of empirical research on barriers and challenges to IoT implementation, but providing academia with a roadmap for future IoT research, thus addressing calls for an IoT specific BM (e.g. Haaker et al., 2021; Krotov, 2017; Le et al., 2019; Turber et al., 2014).

2. Literature Review

2.1 Internet of Things

The term 'Internet of Things' emerged in 2001, when Auto-ID used technologies to automatically identify and trace the flow of goods by assigning electronic product codes to items in their supply chains (Santucci, 2010). Nowadays, IoT is a buzzword, commonly defined as "a system containing everyday devices that have microprocessors and sensors (e.g., sound, movement, and temperature) that are connected to the internet" (van Deursen et al., 2021, p. 258). Despite a number of proposed definitions and lack of universal description, IoT is generally agreed as the increased pervasion and improved integration between the digital and real world (Baldini et al., 2018; Bujari et al., 2018). Research explores various applications of IoT in both private and public sectors. For example, within retail, Bujari et al. (2018) discussed the opportunities IoT affords to create improved customer experiences, secure supply chains and develop new revenue streams. To achieve such benefits, the IoT ecosystem encompasses numerous 'things' equipped with identifying, sensing, and processing technologies (e.g. radio frequency identification, near field communication, sensors), which communicate with one another to accomplish a common useful goal (Krotov et al., 2017; Stergiou et al., 2018; Whitemore et al., 2015). Technologies such as big data, cloud computing, blockchain, 5G and artificial intelligence, then help process, protect and analyse the data generated by IoT objects

(Le et al., 2019; Scholz-Reiter, 2018; Stergiou et al., 2018). These technologies are integral to IoT ecosystem, enabling any "thing" to connect and communicate, transforming the world into an information system. This creates a number of benefits, for example enabling better and more informed decision-making (Krotov et al., 2017; Stergiou et al., 2018), opportunities to automate business processes and drive new sources of value (Noronha et al., 2014). Examples of this include smart shipments, temperature and quality control for logistic companies (e.g. DHL, 2021) or control of machinery, supply chain management, smart robotics, customer satisfaction monitoring and managing warehouse inventories for the manufacturing and retail industry (Manufacturer, 2018; Rawlings, 2019).

2.1.1 Benefits

Scholars have investigated the benefits of IoT (e.g. Scholz-Reier, 2018; Saarikko et al., 2017; Whitemore et al., 2015), antecedents to adoption (e.g. Hsu & Yeh, 2017; Kim et al., 2017; Tu, 2018) and predict the future use of IoT (e.g. Sousa & Rocha, 2019; Bilgeri & Wortmann, 2017). IoT adoption has gained momentum, driven by technological, societal and competitive pressures on organisations to innovate and transform their current offering (Le et al., 2019). A number of factors such as IoT expertise, existing technological infrastructure, management support and external pressure have an impact on IoT adoption (Hsu & Yeh, 2017; Tu, 2018). It has also received much attention as a tool for further development (Bujari et al., 2018). For example, the number of SMART city projects has exploited the opportunities presented by IoT technologies to create better and more sustainable living conditions (Abbate et al., 2019; Sharam et al., 2020). The implementation of IoT technologies is considered a way to gain competitive advantages, pursue new opportunities to innovate and better understand and thus build stronger relationships with consumers (Krotov, 2012; Saarikko et al., 2017). To exploit these benefits “organisations will need to harness the internet of things” (Noronha et al., 2014, p. 8).

IoT presents opportunities to advance service quality, providing improved access to accurate, real-time information to increase the efficiency, effectiveness, service and maintenance of products and services (Noronha et al., 2014; Saarikko et al., 2017). Continual access to real-time data is regarded as one of the main benefits of IoT, to refine existing and improve future decision-making (Abbate et al., 2019; Sousa & Rocha, 2019). For example, Noronha et al. (2014) suggested IoT will drive new sources of value, including potential to automate over half of current business processes. Through optimising processes, they believe organisations will enhance the quality of their products and services, reduce costs, improve decision-making and be better placed to innovate faster, all which translate to significant value. In this way, IoT can save time and money and enhance the way we live and work (Bujari et al., 2017; Lee & Lee, 2015; Whitemore et al., 2015), as well as creating novel opportunities to generate economic benefits (Sousa & Rocha, 2019; Bilgeri & Wortmann, 2017).

2.1.2 Barriers

Before the IoT potential can be fully realised, a number of barriers and challenges must be addressed. Previous studies attempted to categorise barriers to IoT implementation; for example Whitmore et al. (2015) suggested lack of social acceptance and knowledge, the absence of technical accountability and regulation are key barriers. Lee and Lee (2015) noted challenges related to data management, data mining, privacy, security and uncertainty are delaying IoT implementation. Similarly, Bilgeri and Wortmann (2017) identified a need to examine IoT value propositions as the most crucial. Moreover, Westerlund et al. (2014) claimed there are three major challenges; (1) difficulty designing business models for the IoT due to a multitude of different types of connected products, (2) the immaturity of IoT innovations means they are not yet ready to become products and services, and (3) ecosystems are unstructured since it is too early to identify stakeholders and their roles. A recent study by Sharma et al., (2020) outlined 15 barriers to adoption of IoT in the SMART city context, for example; lack of skilled workforce, technical knowledge, integration among networks and no standardisation of regulatory norms.

Uncertainty of how IoT will impact existing business models, organisational strategies, and return of investment are considered significant barriers to implementation (Bilgeri & Wortmann, 2017; Bujari et al., 2018; Sharma et al., 2020). In line with this, it is suggested organisations need to shift focus beyond their internal operations, to examine the entire IoT ecosystem (Lee and Lee, 2015; Westerlund et al. 2014). The successful implementation of IoT requires many different stakeholders to participate in a complex ecosystem, coordinating their activities simultaneously (Lee et al., 2014; Noronha et al., 2014). As such, many organisations encounter challenges identifying horizontal needs and opportunities, aligning internal stakeholders' interests, matching business strategies with technology value and uncertainty because of market immaturity (Westerlund et al., 2014). Challenges related to knowledge transfer within the IoT ecosystem, further add to this complexity (Lombardi et al., 2019). Technical expertise, management support and organisational readiness were found to be important determinants to IoT adoption, and require coordination among multiple stakeholders (Hsu and Yeh, 2017). To overcome the challenges with conflicting stakeholder and strategic interests Westerlund et al. (2014, p.9) recommended that "business model frameworks for the IOT should assume a higher-level perspective to articulate the integrated value of the IOT rather than address the fragmented value drivers".

2.2 Internet of Things - Value Propositions

IoT presents opportunities to redefine industries, create new types of jobs and entirely reshape the nature of work (Bilgeri & Wortmann, 2017; Sousa & Rocha, 2019). Yet, there is much debate in the literature regarding the value of IoT and for whom the value is created. For example, Sun et al. (2012) proposed connectivity itself is an IoT commodity. Similarly, Porter and Heppelmann (2014) and Saarikko et al. (2017) agreed IoT digitisation and connectivity can create opportunities to add value. Whereas others suggested that information is IoTs main value offering (Bucherer and Uckelmann, 2011; Scholz-Reier (2018). However, Saarikko et al. (2017) highlighted that organisations must understand, analyse and use information to inform their decisions, since data alone has no inherent value. For example, Noronha et al. (2014, p. 5) claimed "the primary value that IoT creates is a direct result of the data that can be captured from connected things — and the resulting insights that drive business and operational transformation". Therefore, only when analysed effectively can IoT data provide valuable insights to improve efficiency, effectiveness and better understand consumers to create benefits such as stronger relationships, improved services and predicative maintenance (Le et al., 2019; Scholz-Reiter, 2018). Yet, due to its emergent nature and unknown potential there is much debate surrounding IoT's core competencies and value proposition, which is currently delaying adoption (Sarikko et al., 2017; Sharma et al., 2020).

2.3 Business Models in the era of IoT

The business model concept has gained increased attention in the last decade, for its usefulness in sustainably assisting internet-based and virtual markets to manage new innovative technological advancements (Berman, 2012; Nielsen & Lund, 2014). A business model explains the logic of a firm, the way it operates, and how it creates and captures value from multiple sources (Baden-Fuller & Morgan, 2010).

In the context of IoT, business models are considered "an important driver for the IoT, to motivate companies to invest, reach new markets and generate new revenues" (Bucherer & Uckelmann, 2011, p. 275). Moreover, "business models enable the reengineering of business competencies to adapt to the changing environments" (Haaker et al., 2021, p.128). However, IoT business models have not received sufficient research attention, which has hindered commercialisation and realisation of its full potential (Krotov, 2017; Le et al., 2019). Whitmore et al. (2015, p. 270) discussed the need for organisations to ask questions such as "what are the IoT business models that will drive global business and commerce". Similarly, Abbate et al. (2019, p.183) suggested to address the empirical gap of an IoT business model, organisations should ask questions such as "what different configurations of BM exist in an Internet of Things (IoT) platform?". In the intellectual capital context, Demartini and Paoloni (2017) also proposed adopting a pragmatic why, what, how and when approach. When developing strategies considering new technologies, Massaro and Bagnoli (2015) found strategic intent influences the development of the intangible value and an organisation's relationship with its network, reinforcing the need for a strategic and pragmatic approach to IoT adoption. Haaker et al., (2021) highlighted the need for IoT business models to extend value creation for all stakeholders. There is a need for organisations to design innovative business models suited to the unique characteristics of their specific context, by adopting an ecosystem perspective (Abbate et al., 2019; Nielsen et al., 2018).

A number of studies have started to adapt existing business model frameworks to the IoT context. For instance, Le et al. (2019) and Bucherer and Ucklemann (2011) modified the well-known business model canvas, amending the building blocks to suit the IoT context. However, Westerlund et al. (2014, p. 9) criticised that component based business models such as business model canvas show an expanded view with only specific "parts of the engine", failing to explain the dynamics between components to illustrate "how the engine works". They proposed

IoT business models must encompass the entire ecosystem, rather than specific parts; developing a business model with four value pillars; value drivers, value nodes, value exchanges and value extracts. Sun et al. (2012) also critiqued the business model canvas, suggesting it fails to illustrate cause and affect linkages in relation to IoT processes. They proposed the DNA model, which represents the cause and effect relationship between its three design elements; Data, Needs and Aspirations and can be used by IoT stakeholders to generate and analyse innovative strategies. Chan (2015) proposed the adoption of Hollerer et al.'s (2014) business model to integrate IoT, centred on three dimensions; who (collaborating partners involved in value network), where (sources of value co-creation), and why (benefit from collaborating within the value network) in order to achieve competitive advantages. It is clear IoT presents many opportunities, but it remains up to organisations and their stakeholders to "assemble an approach that is right for their strategic interests and business requirements" (Saarikko et al. 2017, p.675). In this way, the absence of an IoT specific business model is considered one of the main barriers to effective IoT implementation.

In summary, reflecting on extant literature, the current perceptions of IoT incorporate a number of different elements. The drivers of IoT include, but are not limited to; stakeholders, ecosystems, perception of benefits, elements of 'value', perceptions of being driven (or forced) to use IoT, to ensure marketing materials releases and external communications contain the correct 'buzzwords'. Additionally, a number of specific barriers to the use of the IoT are reported in the literature. These include; lack of structured thinking; no clear business model; aspects of data management (privacy, security, chaos); and misunderstanding due to technical novelty and immaturity. Table 1 presents a summary of key themes as identified from extant literature, which informed the design and content of survey questions.

Table 1: Key themes identified from literature

Themes	Author/s
Drivers to IoT adoption	
Access to Information	*Abbate et al. (2019); Le et al., (2019); Lee & Lee (2015); Sousa & Rocha (2019)*
Collaboration with sources	*Le et al. (2019); Lee & Lee (2015); Sousa & Rocha (2019)*
Communication	*Le et al. (2019); Lee & Lee (2015); Lombardi et al. (2019); Noronha et al. (2014)*
Competitive Advantage	*Le et al. (2019); Uckelmann et al. (2018); van Deursen et al. (2021);*
Integration of IoT products	*Abbate et al. (2019); Krotov et al. (2017); Sharam et al. (2020); Stergiou et al. (2018)*
Enhanced relationships	*Bujari et al. (2018); Lombardi et al. (2019)*
Enhanced products and services	*Abbate et al. (2019); Krotov et al. (2017); Noronha et al. (2014); Saarikko et al. (2017); Sharam et al. (2020); Stergiou et al. (2018); Whitemore et al. (2015)*
Gain competitive advantage	*Le et al. (2019); Lee & Lee (2015); Porter & Heppelman (2014); Scholz-Reiter (2018); Stergiou et al. (2018); Whitemore et al. (2015)*
Explore new opportunities	*Le et al. (2019); Porter & Heppelman (2014); Stergiou et al. (2018); Whitemore et al. (2015)*
Be innovative	*Uckelmann et al. (2018); van Deursen et al. (2021)*
Customers' expectations	*Bujari et al. (2018); Krotov (2012); Saarikko et al. (2017)*
Barriers to IoT adoption	
Lack of knowledge	*Hsu & Yeh (2017); ; Krotov (2017); Le et al. (2019); Saarikko et al. (2017); Turber et al. (2014); Tu (2018); Whitmore et al. (2015)*
Security and privacy issues	*Lee and Lee (2015); Saarikko et al. (2017); Westerlund et al. (2014)*
High investment costs	*Saarikko et al. (2017); Sharma et al. (2020)*
Lack of standardisation	*Haaker et al. (2021); Krotov (2017); Le et al. (2019); Turber et al. (2014); Westerlund et al. (2014)*
Unstructured and complex ecosystem	*Hsu & Yeh (2017); Lombardi et al. (2019); Saarikko et al. (2017); Sharma et al. (2020)*

3. Methodology

3.1 Data Collection

This exploratory research adopts a quantitative approach, aiming to investigate aspects of IoT technology within the business model context. A survey was developed to; (1) capture the level of awareness, and identify drivers and barriers of IoT implementation; and (2) identify the factors that positively or negatively influence organisations' decision to adopt IoT technology to develop their business model. To achieve these, we conducted an extensive literature review to gain a holistic overview of the research area to inform survey design (Kauppi et al., 2013). Considering its evolving nature, IoT research remains rather in its infancy, hence Whitemore et al. (2015, p. 262) recommended a need "to consider a wide range of sources for a comprehensive review of the topic". Following the Moore and Benbasat (1991) three-step approach, we developed construct themes, which were derived from reviewing existing IoT literature (see Table 1), which informed the survey design and questions. Considering the relative immaturity of the research field, and to test the validity and relevance of these themes, we employed q-sorting to systematically assess our survey questions. We asked a panel of 12 judges (professionals and academics in the field) to sort these items (q-sample) based on similarities, differences, relevance and coherence. The q-samples were compared, ranked or disregarded depending on the degree to which participants agreed or disagreed with each item (Dziopa & Ahern, 2011). After each round, items were grouped, eliminated or reworded to improve understanding and relevance to address the research questions. This approach has been praised as a process to help optimise understanding and validity of survey questions (Dziopa & Ahern, 2011). According to Nahm et al. (2002), Q-Sorting is a valuable approach in order to ascertain the reliability and validity of developed items.

As a result, an online questionnaire survey (using Qualtrics) was developed and used to increase response rate and reduce collection time (Groves et al., 2011). Adopting snowball sampling, authors made use of existing contacts, using online professional platforms, such as

LinkedIn, to recruit participants (Buchanan et al., 2013). The authors' contacts were predominantly UK based, but some data was also collected from European countries. Considering that the questionnaire was mainly distributed through web accounts, the actual response rate is difficult to indicate. This is one of the disadvantages of this distribution strategy, but we believe that this was a viable approach as a reasonable number of responses was achieved. Specifically, 328 questionnaires were returned, between 1st December 2019 and 5th January 2020. After excluding partial or incomplete questionnaires, 201 were used for data analysis.

3.2 Measures and Data Analysis

The core constructs and variables under investigation have been measured based upon multiple-item and single-item Likert-type scales. The questionnaire included two different sets of questions. First, to test the level of awareness of IoT technology (model 1) participants were asked questions related to access to information (six-item scale, α=.779), external/internal collaboration (three-item scale, α=.821), factors supporting the adoption of IoT technology (communication - three-item scale, α=.816; competitive advantage - three-item scale, α=. 763); factors preventing the adoption of IoT technology (Model 1). Second, to test the willingness of organisations to adopt IoT technology to develop their business model (Model 2), participants were asked the extent to which factors (integration of IoT products, enhanced relationship, enhanced products and services, competitive advantage, new opportunities, be innovative and customers' expectation) influenced their decision to develop their organisations' business strategy considering the IoT technology (Model 2). We employed 5-point Likert scales with a neutral mid-point. The Likert scale adopted included: 'Very Much', 'Moderately', 'Somewhat', 'Slightly', 'Not at all', as suggested by Wade (2006) this scale is most suited to measure awareness and no issues were reported in testing, pilot or live survey. According to

Dawes (2008), 5-point scales are as precise as 7-point scales, but less cognitively challenging and thus yield more reliable responses. Please see Appendix A and B for the measurement items for study constructs.

Two types of statistical techniques were adopted: descriptive and regression analyses. Descriptive statistics have been used to calculate means, standard deviations and correlations among the study variables. Linear Regression Analysis (LRA) was conducted to assess the relationships between pairs of variables (Gravetter & Wallnau, 2011). Two different models were analysed using LRA. Model 1 explores factors influencing the level of awareness of IoT technology and Model 2 identifies the factors that have influenced the strategic decision of organisations to adopt IoT technology in order to develop their business model.

4. Findings

4.1 Profile of Participants

Table 2 presents the profile of participants. Respondents predominantly had a positive awareness of IoT, over half indicated they were moderately (37.56%) to very (27.80%) familiar with IoT technology. Only a small number indicated they had no (6.34%), or a slight (9.27%) understanding of IoT. Over half (52.48%) of participants had a master's degree, qualification or higher (doctoral, 15.84%), illustrating overall high level of qualification among respondents. This correlates with respondents' managerial level, with 61% in top-level management positions, followed by 27% in mid-level management and only 12% lower level management. The majority (31.82%) work in large organisations with over 5000 employees or Small-to-Medium Sized Enterprises (26.26%) with less than 100 employees. Participants came from eighteen different sectors, the highest proportion from education (16%), manufacturing (15%) and transport (13%). Other notable sectors included consultancy (8%), healthcare, retail (6%) and finance (5%).

Table 2: Profile of Participants

Awareness of IoT		Educational Level		Size of Organisation		Managerial Level	
Very Much	27.80%	No Qualifications	0.99%	< 100	26.26%	**Top Management** *Regional/General/Manager; Managing Director; Vice/President/Associate; Co/Founder; Partner; CEO/COO; Principal/Associate/Head; Professor*	61%
Moderately	37.56%	Certificate Level	8.42%	< 250	13.13%		
Somewhat	19.02%	Bachelor Level	12.38%	< 500	9.60%	**Middle Management** *Consultant; Senior/Assistant; Product/Chief/Chain Officer of X; Project/Team Leader/Manager; Manager; Supervisor*	27%
Slightly	9.27%	Masters Level	52.48%	< 1000	19.19%		
Not at all	6.34%	Doctoral Level	15.84%	> 5000	31.82%	**Lower Management** *Student; Data Analyst; Officer; Designer; Assistant; Tech Specialist; Lecturer; Team Member*	12%
		Professional qualification	6.93%				
		Other	2.97%				

4.2 Model 1: Factors influencing Awareness of IoT

Study Variables

In model 1, the data analysis contains 10 variables; each of which was operationalised on a 5-point Likert scale. The dependent variable (1) is the awareness of IoT and variables 2-10 are independent variables (see Table 2). Table 3 presents key descriptive statistics: means, standard deviations and correlations between the model variables. No concerns were raised regarding common method variance or multi-collinearity issues regarding the specific variables in the data set.

Table 3: Means, standard deviation and correlations between study variables (Model 1)

		Mean	SD	1	2	3	4	5	6	7	8	9	10
1	Awareness of IoT	3.71	1.153	-									
2	Combined Access to Info	3.88	1.177	.265**	-								
3	Collaboration with sources	4.31	.936	.243**	.524**	-							
4	Communication	4.23	.964	-.032	.117*	.051	-						
5	Competitive Advantage	4.44	.847	.025	.063	.003	.456**	-					
6	Lack of Knowledge	4.24	.941	.131*	.234**	.231**	.020	.091	-				
7	Security and Privacy issues	4.23	1.000	.160*	.147*	.066	.083	.002	.412**	-			
8	High Investment costs	4.01	.975	.003	.158*	.205*	.099	.122*	.324**	.316**	-		
9	Lack of standardisation	3.90	1.060	.220**	.178*	.094	.132*	.040	.351**	.344**	.199*	-	
10	Unstructured and complex ecosystem	3.79	1.024	.031	.153*	.112	-.030	.068	.366**	.283**	.343**	.412**	-

Note. ** $p < .01$ * $p < .05$ (N=201)

Model 1 Linear Regression Analysis

The outputs of the LRA, represent the best prediction of how the level of awareness of IoT technology can be influenced by the nine independent variables (see appendix C). Table 4 indicates three factors; access to information, collaboration with sources and lack of standardisation, play a significant role in enhancing level of awareness of IoT technology. These revealed respondents have better understanding and knowledge of IoT technology when the appropriate information is provided and they collaborate with key stakeholders. Moreover, it indicates respondents' would feel more confident to use IoT technology if there were a standardised business model framework to guide them on how best to implement IoT. The remaining factors were not significantly related to the level of awareness of IoT technology.

Table 4: Results of LRA: Awareness of the IoT and variables (N = 201)

Variables	*Awareness of the IoT*	
	β	**P**
Access to Information	**.164**	**.042**
Collaboration with sources	**.170**	**.035**
Communication	-.131	.090

Competitive Advantage	.085	.266
Lack of Knowledge	-.007	.933
Security and Privacy Issues	.127	.103
High Investment costs	-.098	.195
Lack of Standardisation	**.213**	**.007**
Unstructured and complex ecosystem	-.110	.164

4.3 Model 2: Factors Influencing Organisations IoT business strategy

Study variables

As seen in Table 5, Model 2 includes 8 variables, and the means, standard deviation and correlation between them. The dependent variable (1) is the business strategy and variables 2-8 are independent variables. Appendix D illustrates the relationship among these variables. No concerns were raised regarding common method variance or multi-collinearity issues regarding the specific variables in the data set.

Table 5: Means, standard deviation and correlations between study variables - Model 2

		Mean	SD	1	2	3	4	5	6	7	8
1	Business Strategy	3.18	1.348	-							
2	Integration of IoT products	3.87	1.045	.424**	-						
3	Enhanced relationships	4.09	.939	.405**	.657**	-					
4	Enhanced products and services	4.14	.872	.428**	.649**	.673**	-				
5	Gain competitive advantage	4.27	.843	.377**	.521**	.574**	.647**	-			
6	Explore new opportunities	4.18	.939	.256**	.475**	.495**	.571**	.668**	-		
7	Be innovative	4.33	.838	.228**	.389**	.431**	.510**	.579**	.576**	-	
8	Customers' expectations	4.18	.853	.208**	.444**	.552**	.589**	.528**	.506**	.440**	-

*Note., ** $p < .01$ * $p < .05$ (N=201)*

Model 2 Linear Regression Analysis

The LRA was conducted to best predict the extent to which the seven independent variables, presented in Table 6, influenced organisations' decision to consider the IoT technology while developing their business strategy. Findings revealed that integrating IoT products, creating enhanced products and services, and to gain competitive advantage, are significantly and positively related to organisations development of a business strategy taking into account IoT technology. As a result, we conclude that participants support that they have or will develop a business strategy considering the IoT technology, if there are opportunities to develop and integrate IoT products, the technology can assist them to improve the quality of the products and services that they provide and gain an advantage against their competitors. The rest of the factors were not found to influence the development of IoT business strategies.

Table 6: Results of LRA: Business Strategy and variables (N = 201)

Variables	***Business Strategy***	
	β	**P**
Integration of IoT products	***.195***	***.031***
Enhanced relationships	*.145*	*.130*
Enhanced products and services	***.219***	***.034***
Gain competitive advantage	***.189***	***.050***
Explore new opportunities	*-.074*	*.416*
Be innovative	*-.028*	*.730*
Customers' expectations	*-.137*	*.099*

5. Discussion and Conclusions

5.1 Discussion

This study examines current issues and future horizons in the rapidly emergent area of IoT. This section discusses our findings, in light of extant literature. The aim of this study was twofold. First we aimed to explore factors influencing or hindering organisations ability to implement IoT. Second, we aimed to identify key criteria of an IoT business model. This section is structured on these two research questions.

Factors influencing organisations ability to implement IoT

IoT is considered one of the most important emerging technologies, offering innovative organisations the chance to transform their current offering (Lee & Lee, 2015; Whitemore et al, 2015). Research identifies numerous supporting technologies, such as artificial intelligence and cloud computing, are required for effective use of IoT (Bagloee et al., 2019; Lombardi et al., 2019; Le et al., 2019; Scholz-Reiter, 2018). This study clearly demonstrates that whilst this is true to an extent, there remain a number of key technologies organisations are not currently engaging with. Findings revealed smart devices (implemented by 64% of participants), cloud computing (implemented by 68% of participants) and sensors (implemented by 39% of participants) were the most important and widely implemented IoT supporting technologies. However, this study reveals that organisations are not currently engaging with a number of key technologies, including; blockchain (has not been implemented by 61% of participants) and 5G (has not been implemented by 74% of participants). This is surprising, given the claimed importance and positioning of these technologies in the academic literature (e.g. Le et al., 2019; Scholz-Reiter, 2018; Uckelmann et al., 2018). Perhaps, this is due to the novelty and relative immaturity of IoT and the current unavailability of technical infrastructure to support their use. Both blockchain and 5G, are recognised as useful technologies to overcome challenges associated with IoT implementation, for example to ease security and privacy concerns, and support higher data volume resulting from increased IoT usage. We predict that these technologies may become more pervasive as the number of organisations implementing IoT increases and technical infrastructure improves. Therefore, this study provides important insights to these innovative organisations, as it investigates the factors that influence their decision to adopt IoT.

Scholz-Reier (2018) acknowledged the need to better understand IoT value creation. There is much debate of the actual value of IoT and for whom that value is created (e.g. Bilgeri &

Wortmann, 2017; Sousa & Rocha, 2019; Scholz-Reier, 2018). Previous research suggests IoT has the potential to redefine industries, create new types of jobs, new opportunities and even to entirely reshape the nature of work. However, our findings reveal a much more pragmatic view of the potential value of IoT. Respondents specifically identified more rational and practical value propositions. Significantly, the opportunity to gain and maintain a competitive advantage, supporting research by Porter and Heppelmann (2014) and Saarikko et al. (2017). It was believed that adoption of IoT would improve an organisations' competitive positioning and ability to compete, pursue new opportunities, better understand their customers and build stronger relationships (e.g. Krotov, 2012; Saarikko et al., 2017). The second most important IoT value proposition was revealed as the ability to provide 'better' services, for example increasing service quality though access to real-time, accurate data to inform decisions (e.g. Abbate et al., 2019; Saarikko et al., 2017). To be able to use data better, emerged as the third most important IoT value proposition. Interestingly, Lee and Lee (2015) reported many challenges when trying to do this, in particular, the fact that problems, challenges and confusion regarding data management, mining, privacy, security and uncertainty are delaying IoT implementation. Moreover, whilst recognising information as IoTs main value offering, Saarikko et al. (2017) highlighted data itself has no inherent value, and organisations often encounter challenges understanding, analysing and using information to inform decisions. In comparison to value aspects previously identified within the literature, these IoT value propositions are perhaps not as ambitious, however, they illustrate tangible sources of potential value add to organisation, strengthening Massaro and Bagnoli (2015) recommendation to adopt practical and strategic thinking when implementing new technologies. Thus, they provide practical and achievable means to obtain IoT value, offering tangible insight into the ways organisations can exploit IoTs potential. This confirms our belief, that the lack of an IoT business model is one of the main barriers to use.

What are the key criteria of an IoT business model?

In response to the heightened and emerging interest in IoT, previous research acknowledges a need to develop an IoT specific business model, to account for its unique context and specific characteristics (Abbate et al., 2019; Krotov, 2017; Le et al., 2019). This study revealed a number of barriers currently hindering the effective implementation of IoT. In particular, as indicated in Table 3, the lack of formal system integration, in the form of a tangible and usable business framework or model, was a primary barrier. This confirms discussion in extant literature of the need to develop an IoT specific business model, considering the unique context and specific characteristics of IoT, to help organisations capitalise on opportunities, create and capture IoT value (Abbate et al., 2019; Westerlund et al., 2014). Research acknowledged the lack of a clear IoT business model, limited number of successful implementations, and unclear return of investment as the main barriers to IoT implementation (Bujari et al., 2018; Krotov, 2017; Le et al., 2019), moreover, Whitmore et al. (2015) agreed. The lack of an IoT business model for organisations is therefore confirmed as the main barrier to adoption. Thus, the development of an IoT business model is essential as key to helping to overcome the survey respondents perceived barriers to implementation.

A number of scholars identified a need to develop an IoT specific business model, which considers the unique context and specific characteristics of IoT, to help organisations capitalise on opportunities, create and capture IoT value (e.g. Abbate et al., 2019; Le et al., 2019). Bucherer and Uckelmann (2011) considered business models an important driver for IoT, in terms of motivating companies to invest, attaining new markets and generating new revenues. This study revealed that organisations actually develop their own strategies to attain company goals, such as: to be innovative, to achieve a distinct competitive advantage, to meet specific cost needs and exploit opportunities as they present themselves (see Table 5). These do not particularly provide a joined-up approach to informing, designing, and implementing the required strategic trajectory of firms, be they technology or otherwise, especially with regard to IoT ecosystems (c.f. Westerlund et al., 2014; Truber et al., 2014). Respondents also revealed the lack of system, connectivity with strategy development and execution as a barrier to IoT use, and only 23% of respondents claim to have been using IoT technologies for between 3-5 years. Furthermore, only 50% have been engaging and exploring the opportunities of IoT for between 1 to 3 years. This appears more reactionary than strategic planning orientated.

With regards to actionable innovation, perhaps a central tenant for the use and application of IoT, Westerlund et al. (2014) conveyed two categories that actually impede it. Firstly, viewing IoT as a technology platform, rather than a business ecosystem. Secondly, shifting focus of the perceived business model or strategy of the firm, ignoring aspects of the ecosystem it exists within, meaning decisions are made in isolation, without a holistic understanding. 74% of respondents identified innovation and collaboration, information and advice from technology companies was seen as most important, closely followed by liaison with the actual end users (72% of participants). This provides some insight into the growing sophistication and focus of organisations within the technology sector; specifically that they are now more directly focusing on the opportunities and advice available. Moreover, there is an increased realisation of the need to understand and address the needs of actual end users. Perhaps an indication of a better balance between the perception of technology being 'pushed' out by technology firms, to the customers starting to 'pull' the technology forward as opportunities are not just perceived, but more directly seeking to be realised. This suggests a necessary shift in, from an internal focus, to an appreciation of the entire IoT ecosystem (Abbate et al., 2019; Nielsen et al., 2018). This is crucial, given that successful IoT implementation, and realisation of IoT value is dependent on the ability of multiple stakeholders to collaborate and coordinate their activities simultaneously (Lee et al., 2014; Saarikko et al. 2017).

To overcome the identified barriers and help organisations exploit IoTs potential, Figure 1 presents our proposed conceptual IoT Business Model – the AIC (Aspiration, Implementation and Contribution) model. The AIC model was developed based on current IoT literature and the findings of this research. Importantly, the AIC model can be used by organisations engaged with or considering the use of IoT technologies. The difficulty of designing business models for IoT lies in the interconnectedness of potentially different systems, as well as the lack of structure in the ecosystems that could potentially be connected through IoT. The AIC model proposes that are important factors that operate together to potentially address the all-important questions and challenges facing any business, namely; why, how and what. This addresses questions raised in extant literatures. The three-phase approach is comparable to Sun et al.s' (2012) DNA model, which includes data, needs and aspirations. However, their model was based on the principle of cause-and-effect relationships, whereas the AIC model considers aspiration and contribution both have an influence on an organisation's ability to implement and develop IoT strategies.

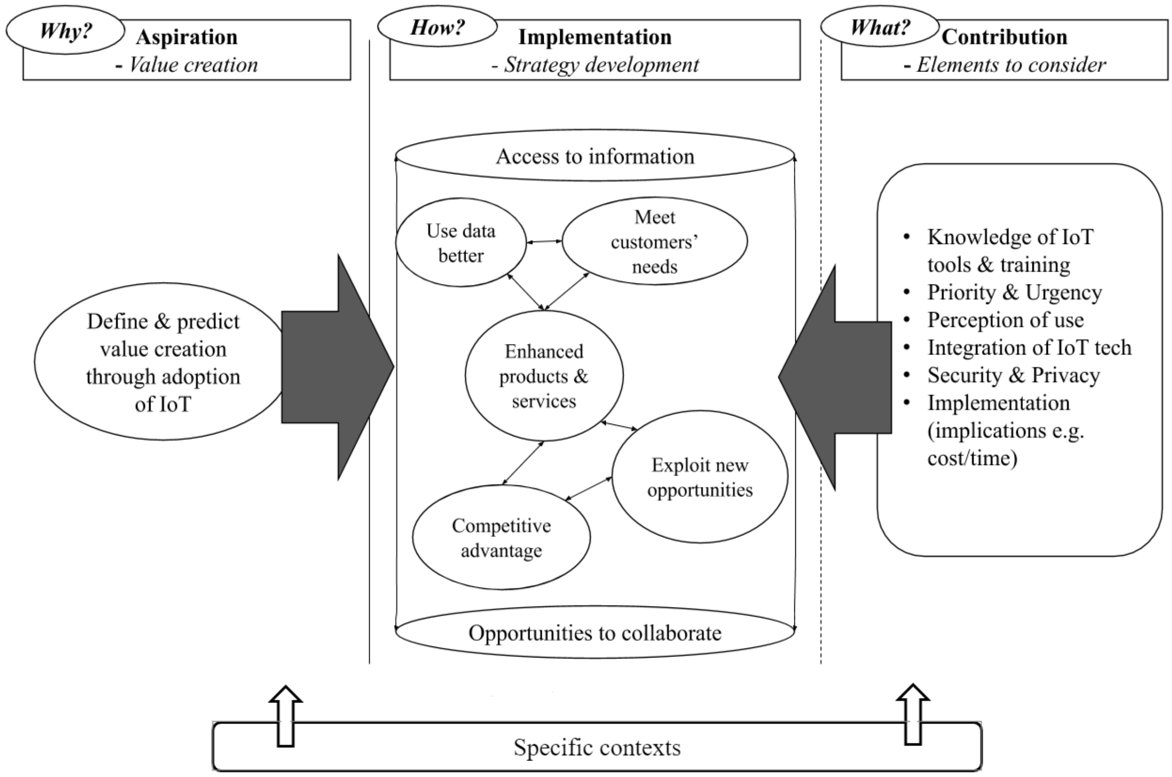


Figure 1: The AIC Business Model

As seen in Figure 1 the AIC model provides focus for context-specific implementation of IoT, identifying key decision phases, and the influence of each on the development of IoT strategies. The model has three phases, whereby, phase 1 and 3 influence phase 2; organisations ability to implement and develop IoT strategies. Crucially, this encourages organisations to think holistically, avoiding only focusing internally, thus not considering the entire IoT ecosystem. Within the aspiration phase, organisations should consider their goals, or the reasons 'why', and how they will create and capture IoT value. The value elements have been identified within this paper as competitive advantage, service provision, using data better. Furthermore, elements of connectivity, digitisation and information provide value additionality for any technology enabled organisation. The next phase, implementation, involves strategy development, encouraging organisations to ask questions, such as 'how' can IoT help them: Use data better (e.g. create useful information and then knowledge from existing datasets); Meet customer needs (e.g. provide customers with the solutions they require); Enhance products and services (e.g. to create additionality for existing products and services – both in-house and for customers); Exploit new opportunities (e.g. to have available capacity and expertise to capitalise on emerging trends); Achieve competitive advantage (e.g. to have knowledge of who the competitors are, what their capabilities are and thereby where unique opportunities/gaps may lie). The next phase, implementation, involves strategy development, encouraging organisations to ask questions, such as 'how' can IoT help them gain competitive advantage or how can they create enhanced products or services. Within this phase, our study specifies that access to information and opportunities to collaborate with other stakeholders (e.g. end users and technology companies) are key enablers of successful IoT strategy development. Hence, their outer position indicates their influence upon the inner factors. Without these, it is likely that organisations will struggle to develop successful IoT strategies. The third phase, which influences implementation, is the contribution or 'what' phase. This is where organisations must consider the practicalities and capabilities, and examine their resources, such as whether they possess the knowledge and skills to successfully implement IoT, or is investment in IoT a priority, or are there other more pressing issues. The AIC business model therefore suggests a sequential approach to ease the interconnectedness of systems and provide direction for the structure required in ecosystems potentially connected through IoT. As shown in Figure 1, the overall AIC business model is context-specific and therefore provides avenues for future research for context-specific validation.

5.2 Theoretical Contributions

The main theoretical contributions of this study are threefold. Firstly and most significantly, the study presents the AIC Model. This bridges a gap in literature, presenting the first conceptual BM in the context of IoT. Crucially, the AIC provides significant insight into implementation and realisation of IoT value. Second, we address a gap in extant literature, that to date has largely focused on technical IoT implementation. Extant research discussing barriers and challenges to IoT implementation is rather disparate, creating difficulties for organisations exploring or trying to exploit the technologies involved. We present a holistic and synthesised insight into the current state of IoT research. This contributes to academia, by providing insight into the main drivers and barriers influencing IoT implementation, as well as progressing current understanding of IoT. In particular, this makes an important contribution to theory, and we hope paves the way for researchers to further explore the barriers, drivers and value of IoT in relation to business models. Thirdly, to address the current lack of research of IoT business models, we outline a roadmap for future IoT research. We hope this contributes to further development of IoT research. In particular, we identified that the creation of value and competitive advantage requires a high level of access to information and tangible opportunities to work together. A lack of knowledge is perceived as being intrinsically linked to low levels of opportunities for working together and rather limited access to information. In general terms, there is a perception of a shift from technology firms 'pushing' IoT, to commercial organisations starting to realise the opportunity and begin 'pulling' IoT and its related applications into the company. To use a phrase from a standard Boston matrix, specific technologies such as smart devices and cloud computing represent the 'Silver bullets' (de Villiers et al. 2016). Furthermore, at present whilst only 20% of respondents said that IoT was driving strategies this will increase in the near future.

5.3 Practical Implications

Overall, the IoT has the potential to have a significant impact on business processes and performance, offering new opportunities to increase efficiency, effectiveness and accuracy as well as saving time and money. Findings reveal a number of relevant managerial and academic insights. Importantly, the study outlines a number of avenues organisations can consider when implementing IoT, to capitalise on the many opportunities it presents. First, this study found that the lack of an IoT business model for organisations is among the main barriers to adoption. Organisations are therefore advised to closely work with their employees to fully understand and capitalise from the AIC business model, understanding its underlying criteria and factors to adopt a context-specific IoT business model. By inference, having a realistic business model will help organisations to use and implement IoT. Second, our study has shown the need to think holistically when it comes to IoT implementation. Rather than keeping to internal decision making, IoT captures its value from the wider ecosystem and therefore companies are advised to take a holistic perspective. Third, IoT is part of a fast-paced and quickly moving technological landscape. Our study has shown that companies need to constantly monitor the IoT environment and look for new opportunities. Working collaboratively and exploiting new opportunities is advised to be the step forward for IoT conscious organisations.

5.4 Limitations and future research

Finally, this study has some limitations. First, the proposed AIC model is based purely on secondary and quantitative research. Hence, to fully understand the 'how' and 'why' of IoT value creation, further qualitative research would provide important implications on the current state of the art of organisations' IoT implementation. Second, this study has not empirically tested the AIC model and therefore, it is suggested further research should apply and thus validate our IoT business model. Whilst our model makes a number of contributions, it is conceptual and therefore the true impact of IoT will not be realised prior to implementation. Third, the model has been proposed through a combination of Q-Sampling with experts and questionnaires with 201 employees. Using a larger sample would increase the ability to generalize the findings to a wider population. Finally, organisations currently using IoT are clearly the early adopters, and we believe as industry users and the general public become more aware of, and confident to use IoT technologies, demand will increase. Interestingly examples of this are the fact that blockchain is still not fully understood and that 5G is really in its infancy. Finally, it is suggested future research could possibly focus on tracking the developing and growing maturity of the application of the IoT within the business community. Future research could perhaps then explore aspects that are still not fully understood, examples of this are the apparent confusion on what block chain actually is, and that 5G is really in its infancy. Furthermore, the challenging aspect of defining value of I OT deserves further specific research and Analysis. Finally, it would be very interesting to track the developing and growing maturity of the application of the IoT within the business community.

References

Abbate, T., Cesaroni, F., Cinici, C., and Villari, M. (2019). Business Models for developing smart cities. A fuzzy set qualitative comparative analysis of an IoT platform. *Technological Forecasting and Social Change, 142*, 183-193.

Baden-Fuller, C. & Morgan, MS. (2010). Business Models and Models. *Long Range Plan. 43*(2-3), 143–145.

Bagloee, SA., Tavana, M., Withers, G., Patriksson, M., & Asadi, M. (2019). Tradable mobility permit with bitcoin and ethereum - a blockchain application in transportation. *Internet of Things,* 8, 100-103.

Berman, S.J., (2012). Digital transformation: Opportunities to create new business models, *Strategy and Leadership*, *40*(2), 16–24.

Bilgeri, D., & Wortmann, F. (2017). Barriers to IoT Business Model Innovation. In Leimeister, J.M. & Brenner, W. (Eds.), *Proceedings der 13. Internationalen Tagung Wirtschaftsinformatik* (pp.987-990) St. Gallen.

Buchanan, D., Boddy, D., & McCalman, J. (2013). Getting in, getting on, getting out and getting back. In Bryman, D. (Ed.s), *Doing research in organisations* (pp.53-67). London: Routledge.

Bucherer, E. & Uckelmann, D. (2011). Business Models for the Internet of Things. In Uckelmann, D., Harrison, M. & Michahelles, F. (Eds.), *Architecting the Internet of Things* (pp. 253-276). Springer: Berlin,

Bujari, A., Furini, M., Mandreoli, F., Martoglia, R., Montangero, M., & Ronzani, D. (2018). Standards, Security and Business Models: Key Challenges for the IoT Scenario. *Mobile Networked Applications*, 23, 147-154.

Chan, H. (2015). Internet of Things Business Models. *Journal of Service Science and Management*, 8, 552-568.

Dawes, J. (2008). Do data characteristics change according to the number of scale points used? An experiment using 5-point, 7-point and 10-point scales. *International Journal of Market Research, 50*(1), 61-104.

Demartini, P., & Paoloni, P. (2017). A path model "why-what-how-when" to implement an IC Reporting. *International Journal of Business and Management, 12*(6), pp. 11-25.

de Villiers, R., Woodside, A.G. & Marshall, R. (2016). Making tough decisions competently: Assessing the value of product portfolio planning methods, devil's advocacy, group discussion, weighting priorities, and evidenced-based information. *Journal of Business Research, 69*(8), 2849-2862.

DHL. (2021). *Internet of Things.* Retrieved from: https://www.dhl.com/global-en/home/insights-and-innovation/thought-leadership/trend-reports/internet-of-things-in-logistics.html. Accessed May 15, 2021

Dziopa, F., & Ahern, K. (2011). A systematic literature review of the applications of Q-technique and its methodology. *Methodology: European Journal of Research Methods for the Behavioural and Social Sciences, 7*(2), 39–55.

Gravetter, F. & Wallnau, L. (2011). Essentials of Statistics for the Behavioural Sciences. Belmont, USA: Cengage Learning.

Groves, RM., Folwer, FJ., Couper, MP., Lepkowski, JM., Singer, E., & Tourangeau, R. (2009). *Survey Methodology,* John Wiley & Sons: Canada.

Haaker, T., Ly, P. T. M., Nguyen-Thanh, N., & Nguyen, H. T. H. (2021). Business model innovation through the application of the Internet-of-Things: A comparative analysis. *Journal of Business Research*, *126*, 126-136.

HPE. (2021). *What is the Industrial Internet of Things?.* Retrieved from: https://www.hpe.com/uk/en/what-is/industrial-iot.html. Accessed 15 May, 2021

Hsu, C. W., & Yeh, C. C. (2017). Understanding the factors affecting the adoption of the Internet of Things. *Technology Analysis & Strategic Management,* 29(9), 1089-1102.

Krotov, V. (2017) The Internet of Things and new business opportunities. *Business Horizons, 60,* 831-841.

Kauppi, K., Moxham, C., & Bamford, D. (2013) Should we try out for the major leagues? A call for research in sport operations management, *International Journal of Operations & Production Management*, *33*(10), 1368 – 1399.

Kim, Y., Park, Y., & Choi, J. (2017). A study on the adoption of IoT smart home service: using Value-based Adoption Model. *Total Quality Management & Business Excellence,* 28(9-10), 1149-1165.

Le, DN., Tuan, LL., & Tuan, MND. (2019). Smart-building management system: An internet-of-things (IoT) application business model in Vietnam. *Technological Forecasting and Social Change*, *141*, 22-35.

Lee, I. & Lee, K. (2015). The Internet of Things (IoT): Applications, investments, and challenges for enterprises. *Business Horizons, 58,* 431-440.

Lombardi, R. (2019). Knowledge Transfer and organisational performance and business processes: Past, present and future researches. *Business Process Management Journal, 25*(1), 2-9.

Manufacturer (2018). *Applications of IoT in Manufacturing Plants.* Retrieved from: https://www.themanufacturer.com/articles/applications-iot-manufacturing-plants/. Accessed May 13, 2021

Massaro, M., & Bagnoli, JD. (2015). Where there is a will there is a way, *Journal of Intellectual Capital, 16*(3), 490 – 517.

Moore, G. C., & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information Systems Review,* 2, 192–222.

Nahm, A. Y., Rao, S. S., Solis-Galvan, L. E., & Ragu-Nathan, T. S. (2002). The Q-sort method: assessing reliability and construct validity of questionnaire items at a pre-testing stage. *Journal of Modern Applied Statistical Methods*, *1*(1), 15.

Nielsen, C., Lund, M., Montemari, M., Paolone, F., Massaro, M., & Dumay, J. (2018)*. Business Models: A Research Overview.* London: Routledge.

Nielsen, C., & Lund, M. (2014) *An Introduction to Business Models.* London: Routledge.

Porter, M, E. & Heppelmann, J, E. (2014). How smart, connected products are transforming competition*, Harvard Business Review*, *92*(11), 11-64.

Rawlings, K. (2019). *How IoT Technology is Revolutionizing the Retail Industry*. Retrieved from https://www.mytotalretail.com/article/how-iot-technology-is-revolutionizing-the-retail-industry. Accessed January 10, 2021

Saarikko, T., Westergen, U, H. & Blomquist, T. (2017). The Internet of Things: Are you ready for what's coming? *Business Horizons, 60,* 667-676.

Santucci, G. (2010). The Internet of Things: Between the Revolution of the Internet and the *Metamorphosis of Objects.* Retrieved from: http://ec.europa.eu/information_society/policy/rfid/documents/iotrevolution.pdf. Accessed January 13, 2021

Scholz-Reiter, B. (2018). The internet of things- threats and opportunities of improved visibility, In Uckelmann, D., Harrison, M., & Michahelles, F. (Eds.), *Architecting the Internet of things,* Springer, Berlin.

Sharma, M., Joshi, S., Kannan, D., Govindan, K., Singh, R., & Purohit, H. C. (2020). Internet of Things (IoT) adoption barriers of smart cities' waste management: An Indian context. *Journal of Cleaner Production,* 270, 122047

Sousa, M, J., & Rocha, A. (2019). Skills for disruptive digital business. *Journal of Business Research, 94*, 257-263.

Stergiou, C., Psannis, K., Gupta, B. & Ishibashi, Y. (2018). Security, privacy & efficiency of sustainable Cloud Computing for Big Data & IoT, *Sustainable Computing: Informatics and Systems, 19*, 174-184.

Sun, Y., Yan, H., Lu, C., Bie, R & Thomas, P. (2012). A holistic approach to visualising business models for the internet of things. *Communications in Mobile Computing, 1*, 1-7.

Tu, M. (2018). An exploratory study of Internet of Things (IoT) adoption intention in logistics and supply chain management. *The International Journal of Logistics Management.* 29(1), 131-151.

Turber S., vom Brocke J., Gassmann O., & Fleisch E. (2014). Designing Business Models in the Era of Internet of Things. In Tremblay M.C., VanderMeer D., Rothenberger M., Gupta A., & Yoon V. (Eds.), *Advancing the Impact of Design Science: Moving from Theory to Practice.* (pp.17-31). Springer, Cham.

Uckelmann, D., Harrison, M., & Michahelles, F. (2018). An Architectural approach towards the future internet of things. In Uckelmann, D., Harrison, M., & Michahelles, F. *Architecting the Internet of thing* (pp.1-24), Springer, Berlin.

Wade M. (2006). Likert-type scale response anchors. Clemson International Institute for Tourism and Research Development, *Department of Parks, Recreation and Tourism Management. Clemson University.*

van Deursen, A. J., van der Zeeuw, A., de Boer, P., Jansen, G., & van Rompay, T. (2021). Digital inequalities in the Internet of Things: differences in attitudes, material access, skills, and usage. *Information, Communication & Society*, *24*(2), 258-276.

Westerlund, M., Leminen, S., & Rajahonka, M. (2014). Designing Business Models for the Internet of Things. *Technology Innovation Management Review, 4,* 5–14.

Whitemore, A., Agarwal, A., & Xu, L,D. (2015). The Internet of Things - A survey of topics and trends. *Information Systems Front, 17*, 261-274.

Appendix A:

Model 1: Measurements items for study constructs

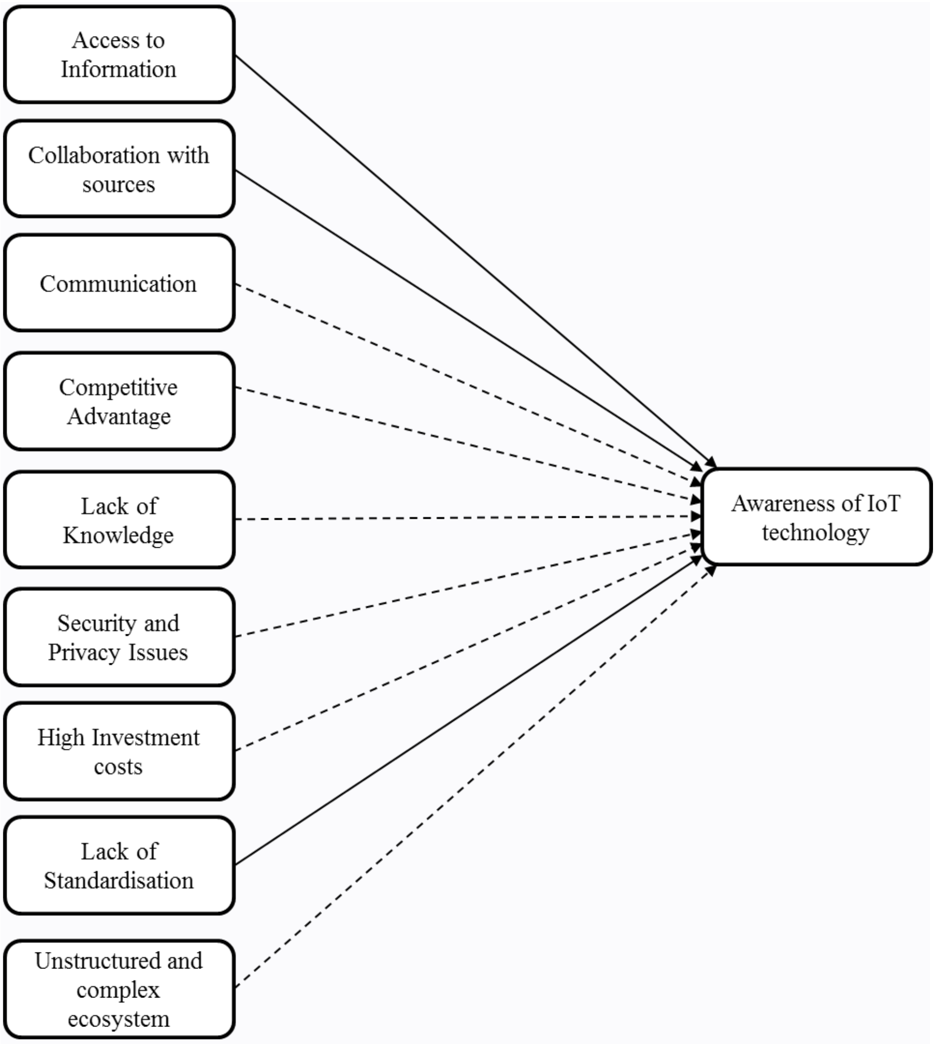
Variable	Survey items	Measurement	Cronbach's α
Factor 1 Awareness of IoT	To what extent are you familiar with the internet of things?	(1 = Not At All, to 5 = Very Much)	-
Factor 2 Access to Information	Access to information from the following sources is important to support the Implementation of the Internet of Things? - *Your organisation; Other technology companies; End users; Marketing and advertising agencies; Government; Public or private research institutes*	(1 = Not At All, to 5 = Very Much)	.779
Factor 3 Collaboration with sources	Collaboration with the following sources is important to implement the Internet of Things Technology? - *End users & other technology companies; Your organisation*	(1 = Not At All, to 5 = Very Much)	.821
Factor 4 Communication	To what extent do you think the following factors are important in your organisations' implementation of the Internet of Things Technology? - *Share information more efficiently; More transparent sharing of best practice internally/externally; enhance communication between partners, stakeholders and networks*	(1 = Not At All, to 5 = Very Much)	.816
Factor 5 Competitive Advantage	To what extent do you think the following factors are important in your organisations' implementation of the Internet of Things Technology? - *Maintain a competitive advantage; Generate Economic Benefits; Create New Business Opportunities*	(1 = Not At All, to 5 = Very Much)	.763
Factor 6 Lack of Knowledge	To what extent do you think the following factors are barriers to the use of IoT?	(1 = Not At All, to 5 = Very Much)	-
Factor 7 Security and Privacy Issues	To what extent do you think the following factors are barriers to the use of IoT?	(1 = Not At All, to 5 = Very Much)	-
Factor 8 High Investment costs	To what extent do you think the following factors are barriers to the use of IoT?	(1 = Not At All, to 5 = Very Much)	-
Factor 9 Lack of Standardisation	To what extent do you think the following factors are barriers to the use of IoT?	(1 = Not At All, to 5 = Very Much)	-
Factor 10 Unstructured and complex ecosystem	To what extent do you think the following factors are barriers to the use of IoT?	(1 = Not At All, to 5 = Very Much)	-

Appendix B

Model 2: Measurements items for study constructs

Variable	Survey items	Measurement	Cronbach's α
Factor 1 Business Strategy	To what extent the following factors were important in your decision to develop or not your business strategy considering the Internet of Things technology?	(1 = Not At All, to 5 = Very Much)	-
Factor 2 Integration of IoT products	It is critical for businesses to integrate IoT into products and services	(1 = Not At All, to 5 = Very Much)	-
Factor 3 Enhanced relationships	Enhance relationship with customers, suppliers, networks…	(1 = Not At All, to 5 = Very Much)	-
Factor 4 Enhanced products and services	Enhanced products and services	(1 = Not At All, to 5 = Very Much)	-
Factor 5 Competitive advantage	Gain a competitive advantage	(1 = Not At All, to 5 = Very Much)	-
Factor 6 New opportunities	Exploit new opportunities	(1 = Not At All, to 5 = Very Much)	-
Factor 7 Be innovative	Be innovative	(1 = Not At All, to 5 = Very Much)	-
Factor 8 Customers' expectations	Customers' expectations	(1 = Not At All, to 5 = Very Much)	-

Appendix C: Relationship between level of awareness and related variables



Appendix D: Relationship between business strategy and related variables