# The Influence of Risks on the Outturn Costs of ICT Infrastructure Network Projects

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**Purpose-** The Internet of Things (IoT) is becoming an increasingly inescapable part of society. The IoT paradigm can not function without the networking infrastructure. High-speed data networks are essential to enable the IoT future. Thus, the focus of this research is on the identification of risks that influence the development, installation, and operation of ICT infrastructure network projects' cost outcomes. So far, there has been little attention paid to risk problems in these types of IoT enabling projects.

**Methodology-** This research follows a quantitative analysis approach. Data for this study was collected by a survey of 209 professionals. Multiple regression analysis was used to model the relationship between risks and outturn cost of infrastructure needed to enable the operation of IoT technologies.

**Findings-** The main risk factors that were identified were planning and development, people and management, operations, technology, and hardware.

**Implications-** This research has expanded the existing literature by documenting and clustering ICT infrastructure network project risks into themes, and has developed a scale (risk statements) for measuring such risks. This research has advanced our understanding by identifying the most likely risks that will contribute to the overrun of these projects.

**Originality/ value-** This research establishes a reliable regression method for the assessment of the risks that influence the development, installation, and operation of ICT infrastructure network projects' outturn costs. No other research has measured or studied the risks of these types of projects.

**Keywords:** IoT, Risk factors, risk management, network projects, cost overruns, outturn costs.

**Manuscript type:** Research paper

## Introduction

The Internet of Things is becoming an increasingly inescapable part of society (Miller, 2015). This will require a giant network of connected devices and physical infrastructure (Vaidya et al., 2017). Big data, simulation, autonomous robots, augmented reality, cloud computing, and IoT are the technologies that will help to transform cities, businesses, industries, and government services into smart entities through information and communications technology networks and data analytics (Njoki, 2016; Moktadir et al., 2018; Kamble et al., 2018). This is achieved via communication networks integrated with other vital systems such as clouds, virtual networks, smart grids, etc., (Delport et al., 2017). The IoT paradigm can not function without extensive networking infrastructure (Kamble et al., 2018 ). It was pointed out that one of the main hurdles to IoT widespread implementation is the shortage of available fiber-optic infrastructure (Henriques et al., 2020; De Cremer et al., 2017). Others pointed out that "IoT projects are hybrid IT projects" (De Cremer et al., 2017). That is to say, IoT technologies are based on the use of traditional IT systems integrated with cloud environments (De Cremer et al., 2017). It is argued that IoT projects succeed best when integrated with IT systems (Moktadir et al., 2018). Thus, the implementation of IoT technology to a large extent depends on the physical networking infrastructure for data capturing, transfer, storage, and analysis (Henriques, 2020).

Dekkers and Forselius (2007) defined an ICT project as a project that is focused on the development and installation of a new software product. In contrast, ICT infrastructure network projects (sometimes these projects are termed ICT infrastructure physical assets) are associated with the infrastructure required to connect computers, data loggers, printers, switches, telecommunications, servers, cabling, data rooms, civil works, etc., for exchanging data, i.e., communication (Dordal, 2009). Networks are physical assets that deliver information systems, which, in turn, host databases and software (i.e. ICT). Information and communications technology is the infrastructure and components that enable people and organisations to interact in the digital world (Wong and Kim, 2017). ICT infrastructure assets are of paramount necessity for IoT global infrastructures which enable services by connecting physical devices and virtual things based on existing and evolving information and communication technologies (Wong and Kim, 2017; Vaidya et al., 2018). Thus, the IoT infrastructure depends largely on internet communication protocols, internet gateways, and cloud-based platforms for data transfer from IoT devices to event processing and real-time analytics platformers (Kamble et al., 2018). Hence, this research is aimed at investigating the risks that contribute to the cost outcomes of ICT infrastructure physical assets (civil engineering works) that are necessary for the development, installation, and operation of IoT technologies and IT systems.

A large number of investments are directed towards ICT infrastructure physical assets that help in designing smarter cities that offer a better quality of life to residents and better business processes (Nijkamp and Cohen-Blankshtain, 2013). Also, governments can benefit from ICT infrastructure physical assets as they are able to meet their development objectives in a cost-effective manner (Henriques, 2020). Furthermore, in the opinion of Kaba and Said (2014), ICT infrastructure assets help to improve communication as well as the exchange of knowledge and information, which is a necessity for the development process, thus helping organisations to achieve their developmental goals (Minto-Coy, Bailey and Thakur, 2015). While the idea of adopting IoT services into society is a positive one, the road is fraught with many challenges when it comes to the development, installation, and operation of ICT infrastructure physical asset projects (Moktadir, 2018). Cost overruns, delays, change of scope, lack of specification, failed procurement, or unavailability of financing are very common (Flyvbjerg and Budzier, 2011; Anthopoulos et al., 2016). Cost overruns are not a new phenomenon. It is a problem that has puzzled both academics and industry for decades. Although there has been ample evidence in the literature on issues and factors that lead to cost overrun in construction projects, there is sparse literature that focuses on the cost overrun of ICT infrastructure physical assets projects. It is claimed that the majority of projects' overspent problems are due to a lack of professional, forward-looking risk management (Flyvbjerg and Budzier, 2011). As reported widely in the literature, large ICT infrastructure projects suffer from significant under the management of risk at all stages of the value chain (Anthopoulos et al., 2016). These projects suffer from poor risk assessment and risk allocation, leading, in most cases, to eroding a significant share of their benefits realization value (Lappi et al., 2019). According to Anthopoulos et al. (2013), ICT infrastructure network projects tend to deviate by more than 10% from their original initial cost estimates. Other researchers highlighted the fact that there is a strong relationship between risk factors, delays, and cost overruns (Taylor, 2015). Existing literature mainly addresses risks and cost overruns in ICT projects (i.e., information technology projects), whereas the risks and cost outcomes of ICT infrastructure network projects (as defined above) are under-investigated. Furthermore, in the UAE, there is considerable interest in developing ICT infrastructure. While there has been some success in establishing e-services infrastructure, the development still lags behind the developed world. The UAE amis to extend this positive impact on governance and is thus looking to expand ICT infrastructure systems that would make the processes and services faster and more reliable (Halaweh, 2018). There has been little or no research concerning the risks that influence ICT infrastructure projects' cost outturn in the UAE context and internationally. Thus, this research aims to expand the existing literature by documenting and clustering ICT infrastructure network project risks into themes and clusters and developing a scale (risk statements) for measuring such risks. Further, the research intends to advance the knowledge of ICT infrastructure network projects by identifying the most likely risks that will contribute to cost outcomes.

The findings of this research will document a list of risks related to the life cycle of ICT infrastructure projects' development, installation, and operation. Further, the results will demonstrate which of these risks have an influence on the cost outcomes of ICT infrastructure projects. By documenting, analysing, and discussing the influence of risks on the outcome of ICT physical asset projects, the study builds an initial understanding of the challenges of constructing and operating network infrastructures for future IoT technology, and consequently, contributes to the ICT infrastructure projects literature. The managerial and professional implications of the findings allow stakeholders to understand the risks that influence cost outcomes when making initial project development decisions and during development and operation phases. The results will assist them to develop appropriate risk management and mitigating strategies. The risk list might also be useful as an indicator for investors who might be interested in procuring ICT infrastructure for IoT technologies. The rest of the paper is organized into five sections: literature review and hypotheses development, research methods, results, discussion, and conclusions.

## Literature Review and Hypothesis Development

In the digital era, there is a growing realization that technology and innovation are the keys to improving business performance, and nations' economies, as well as the well-being of global citizens (Anderson et al., 2015). With the advent of an increasingly pervasive internet, which is being facilitated by several disruptive technologies, it has become essential for the private and government sectors to operate in such a technologically advanced environment (Henriques, 2020). It is claimed that ICT network infrastructure coupled with IoT technology will also increase productivity, improve the quality of life, and create more jobs (Henriques et al., 2020; Cordella and Tempini, 2015). Internet-based applications and IoT devices can be utilized for data collection and transmission, and provide the necessary infrastructure for information dissemination and communication with the masses (Delport, Von Solms and Gerber, 2016; Wong and Kim, 2017). It is, however, important that the ICT infrastructure projects and IoT technology are aligned with society's requirements as well as the businesses' processes (Botnariuc and Fat, 2011; Moktadir, 2018). To realize these benefits, one must understand that ICT infrastructure assets are dependent on certain central functions such as operations, management of services, and quality maintenance (Taylor, 2015; Lappi 2019). The development, construction, installation, and operation of these assets require due care, otherwise, these systems will be subjected to future security threats due to disruptions, outages, and security breaches (Wong and Kim, 2017). Thus, the procurer must identify possible risks at an earlier stage of development so that a robust and reliable infrastructure network is developed. This should form a part of the core ICT infrastructure assets specification (Gatautis et al., 2015). While the idea of adopting IoT to run businesses and governmental services is a positive one, the road is fraught with many risks when it comes to the development, installation, and operation of ICT network infrastructure. One of the risk factors that need to be considered is the fact that technology is evolving rapidly, and public and private sector organizations are not able to keep up with these changes (Rana et al., 2015; Lappi, 2019). ICT infrastructure network components may quickly become obsolete. The feasibility and evaluation of the cost of ICT infrastructure network projects – across all phases –poses a problem due to optimism bias (Flyvbjerg and Budzier, 2011; Anthopoulos et al., 2016, Lappi et al., 2019), yet there is no standard procedure that can be universally applied to solve the problem of optimism bias in large projects (Khalifa et al. 2001; Flyvbjerg and Budzier, 2011). To illustrate this, Hutton (2019) presented several case studies to demonstrate how the epidemic is the cost overruns of major governments. It was pointed out that the main reason for the failure of ICT network projects is poor project design and management (Guha and Chakrabarti, 2014). The majority of these problems are due to a lack of professional, forward-looking risk management (Flyvbjerg and Budzier, 2011). These projects suffer from poor risk assessment, leading, in most cases, to the erosion of a significant share of their benefits realization value. In the opinion of Weiss and Anderson (2004), the failure due to risk can be reduced considerably by making use of well-established risk approaches along with business processes to manage the development and operation of ICT infrastructure projects.

Risk leads to delays in the project, which in turn leads to consequences for cost outcomes (Hutton, 2019). Risk in a project is viewed as an uncertain event or an occurrence that has a negative effect on project objectives and may cause delays in project completion (Flyvbjerg and Budzier, 2011). Thus, this research addresses risks that are associated with developing, installing, and operating ICT infrastructure physical asset projects for supporting IoT technology implementation. These risks are grouped into four major categories: Planning and Development, People and Management, Operations, and Technology and Hardware. The following sections review and extract the risks associated with these clusters.

***Planning and Development Risks***

Development risks are associated with the initializing, planning, developing, and installation of ICT infrastructure network projects and their associated processes (Elzamly and Hussin, 2015). In the opinion of Nawi et al. (2012) and Lappi et al. (2019), for ICT infrastructure network projects to be successful, there needs to be a number of steps undertaken by the organization, which usually involves initializing, planning, developing, and implementing the project. According to Sherwood (2005), human resource mismanagement in the development of ICT infrastructure network projects can have severe implications for the entire process. The author goes on to argue that managers also need to ensure that there is easy integration of the ICT infrastructure network projects scope with the business processes of the organization (Sherwood, 2005). Being on schedule and on the budget is not sufficient for the success of the project; it must also be in sync with the business strategy (Ab Razak and Zakaria, 2015; Lappi et al 2019). Dutta and Coury (2002) and Adomi (2010), cited communication and fulfillment of roles by stakeholders as an issue in development procurement. This view is supported by Lappi et al. (2019). The authors advocated that managers need to develop a well-thought-out communication strategy and to form project alliances. Malik et al (2014) asserted the importance of common understanding regarding what should be included in and what should be excluded from infrastructure network projects during project scope development. Similarly, Anthopoulos et al. (2016) stressed the imperativeness of stakeholders having a good understanding of the scope of the project in order to be able to determine the budget and time frame. A well-developed infrastructure network project charter will spell out the project scope, resource pool, and resource requirements based on the objectives and bill of requirements (Malik et al., 2014; Lappi et al., 2019). In the absence of a robust project schedule, mismanagement, delays, and monitoring problems, and cost overruns will undermine project success (Matavire et al., 2010). This is of great importance to projects that are strongly time-constrained. The summary of the risk factors list for the four categories extracted from the literature is presented in Table I. Awareness of these risks is required to make risk-informed decisions about the development of ICT infrastructure network projects. This will lead to reducing vulnerability and exposure, and increasing chances for success. Therefore, the first research hypothesis is posited as follows:

**H1:** *Planning and Development risk factors will influence ICT infrastructure network projects' cost outcomes.*

**Insert Table I about here**

***Technology and Hardware Risks***

Hardware and software failures are prominent in the technology industry (Lappi et al., 2019). Also, high-speed innovation in the ICT sector comes with numerous emerging risks. Lack of technical know-how along with practical training is a major cause of the failure of ICT projects (Mahendra et al., 2014; Wong and Kim, 2017; Hutton 2019). Furthermore, in the opinion of Mahendra et al. (2014), lack of clarity regarding the concept of ICT components causes ICT network project failures. In the view of Tearle (2003), it is imperative that heavy investment be made not just to procure the technology but also to upskill the workforce. Warren et al (2008), raised the issue of whether organizations should develop products and solutions that are flexible with the ICT infrastructure. Similarly, others have promoted the idea that integration of new technologies with existing technologies is one of the most changing risks in network development (Bouwman et al., 2005; De Cremer et al., 2017; Hutton, 2019). Several authors cited failure to address integration with existing technologies, ‘failure to address the integration of components within the project’, ‘failure to provide supporting infrastructure on time’, ‘technology failures caused by unstable project team’ and ‘technical failures caused by quality mismanagement’ (Nawi et al., 2012; Mahendra et al., 2014; Anthopoulos et al., 2016; Lappi et al., 2019; Hutton, 2019). The main risk factors under this category are presented in Table I. These risks have an important influence on the procurement and operation of ICT network technical components (Anthopoulos et al., 2016; Moktadir, 2018; Lappi et al., 2019). It is pointed out that these risks lead to extended phases and delays, and in many cases, they may also result in complete failure of the ICT network and may lead to additional planning time and resources (Moktadir, 2018; Lappi et al., 2019). Therefore, the second research hypothesis is posited as follows

**H2:** *Technology/Hardware risks will influence ICT infrastructure network projects' cost outcomes.*

***Operational Risks***

Despite the robustness of the ICT infrastructure, many networks tend to experience hardware and software downtimes and outages (Bekkers and Thaens, 2005; De Cremer et al., 2017). ICT infrastructures are even prone to instability due to disruptions or failing components (Shackleton et al., 2004; Wong and Kim, 2017). It is noted that, if there is persistent instability in the delivered network, it becomes susceptible to attacks and outside threats (Satapathy et al., 2014). According to Touray, Salminen, and Mursu (2013), unplanned outages are majorly caused by ill-planned changes implemented prematurely in the organization. In Meijer's (2015) opinion, it is the responsibility of the managers to solve issues relating to unplanned outages. Adoption of a formalized approach towards management of operational change will help to deliver a more efficient and organized ICT infrastructure (Leydesdorff and Wijsman, 2007). Other studies (Camarinha-Matos et al., 2008; Anthopoulos et al., 2016; Moktadir, 2018; Lappi et al., 2019; Hutton 2019) have suggested various operational risks, which are summarised in Table I. ICT network infrastructure is susceptible to these operation-related risks and the obsolescence risks are growing rapidly due to technology innovation (Vaidya et al., 2018). Therefore, the third research hypothesis is theorized as follows

***H3****: Operational risks will influence ICT infrastructure network projects' cost outcomes.*

***People and Management Risks***

The development and operation of ICT infrastructure network projects represent a profound change that will bring about organizational processes and methodologies (Anthopoulos et al., 2016; Moktadir, 2018; Lappi et al., 2019). Infrastructure network projects' technical managers' lack of control over the complexity of the processes of these projects is a major contributor to negative cost outcomes (Leydesdorff and Wijsman, 2007; Lappi et al., 2019). ICT Infrastructure network project governance, according to Balocco et al (2013), is pivotal in providing the right direction for ensuring that the ICT projects within the organization are able to meet the vital objectives (Henriques et al., 2020). The development, installation, and operation of ICT infrastructure network projects is directly affected by the shortage of skilled management (Mueller-Jacobs and Tuckwell, 2012; Moktadir, 2018; Lappi et al., 2019). Ab Razak and Zakaria (2015) are of the opinion that there are many inefficiencies in the management of ICT infrastructure network projects. According to Bin-Abbas and Bakry (2014), communication is severely lacking and inadequate in these types of complex projects. The alignment between infrastructure network projects, business communication, and the workforce is viewed as one of the biggest risk factors influencing the implementation of ICT networks (Loukis et al., 2016). Numerous publications (De Vries, 2011; National Research Council, 2000; Anthopoulos et al., 2016; Lappi et al., 2019) have cited people and management risks. A Summary of people and management risks is presented in Table I. By addressing these risks, the chances of successful implementation of the ICT network projects can be increased. Thus, the fifth research hypothesis is posited as follows

***H4****: People and Management risks will influence ICT infrastructure network projects' cost outcomes.*

A summary of the variables and their underlying factors is presented, and the four hypotheses are summarized in Figure 1.

**Insert Figure 1 about here**

**Methodology**

The data was collected via an online questionnaire. The questionnaire consisted of risk factors (as independent variables), project cost outcomes due to risk (as a dependent variable), and several demographic questions. This research was aimed at gauging the perception of experts on the likelihood of risk influence on the project outturn cost at a point in time ((Bryman and Bell, 2007). This method is claimed to be associated with objective and accurate data collection to explain a particular existing phenomenon (Bird, 2009). Questionnaires are one of the most common ways of gathering data. The structure of the questionnaire is based on the main study variables obtained from the literature review section. Table I and Figure 1 provide a summary of the variables, as well as their underlying factors and measurements.

To model the relationship between ICT infrastructure risks and outturn cost, this research uses multiple regression. It is a method by which one drives the magnitude and significant contribution of each of the independent variables. Multiple regression analysis is used to test the initial hypotheses, according to the theoretical framework of the study (Almarri and Boussabaine, 2017). This method of modelling is widely used in developing predictive models (Boussabaine and Kirkham, 2005).

This study utilized the Likert Scale as proposed by Boone & Boone (2012). A five-point Likert Scale was adopted. This is a well-structured process for collecting primary data (Saunders et al 2019). Questionnaires permit investigators to collect data to explain cause-effect relationships among research constructs (Field 2018). However, data collection through questionnaires only resent a snapshot of the state of the problem being investigated at one point in time. Thus, the risk constructs drawn from the literature may change. The cause-effect is difficult to prove in a dynamic, changing environment. Although the data will shed light on the association between risks and cost outruns, it will not explain the underpinning reasons for the cause-effect (Field 2018). Other well-known limitations of data collection are documented in Saunders et al (2019).

This study followed the non-probability sampling method suggested by Uprichard (2013). The authors utilized non-probability sampling with a convenient sample (Uprichard, 2011). The benefits include its simplicity, which guarantees easy access to respondents (Etikan et al., 2016). Therefore, convenience sampling was the best choice for this research because it leads to a sampling process that is focused on using criteria that allow relevance to the research goals (Uprichard, 2011). There is no available database on the number of professionals directly involved in ICT infrastructure network projects. Rose, et al. (2014) proposed the following equation for deriving the sample size where the population is unknown:

$$n = \frac{(1.96)^2 pq}{d^2}$$

Where n denotes then is the sample size, p = proportion of the professionals involved in the development of ICT infrastructure (q = 1-p and d = the margin of error). Using a conservative estimate that 8 percent of professionals working in ICT infrastructure (p= 0.08, q =1-0.08= 0.92), and based on a standard 5 percent margin of errors (SE= 0.05) at a confidence level of 95 percent, the minimum sample size (s) would be N = $(1.96)^2$ (0.06) (0.94)/$0.05^2$ =86.

To eliminate bias (inconsistency between the actual population and the selected sample), it was ensured that all respondents were from the ICT infrastructure industry in the UAE. Further, Harman's Single-Factor test was used to check for common bias. All the questionnaire items (except the demography data) were put into factor analysis to check whether the construct loads only one component. The results showed that 18 distich components accounting for 79% of the total variance. Further, the first component only captured 13% (this is below 50% threshold value) of the variance in data. Thus, the results support the evidence that common bias does not exist.

The estimated number of emails sent with the survey invitation corresponded to 1500, of which 209 responses were received. Participants are all working at various levels and positions in the IT and systems departments. Out of the 209 participants, 105 participants worked as IT Managers, 73 as Systems Managers, 15 as Systems Engineers, and 16 as Operations Managers. Out of the 209 participants, 194 were male and 15 were female. The ratio of gender demographics is skewed in favour of males, as 92.8% of the respondents were males while a mere 7.2% were females. A high number of participants (105) had a total work experience of 16 to 20 years, 73 had more than 21 years of experience, 16 had 11 to 15 years of experience and the remaining 15 had eight to 10 years of experience. Out of the 209 respondents, 152 respondents had completed their master's degree, 24 had a bachelor's, 17 had acquired a PhD and 16 had diploma education.

The internal reliability of the study instrument was tested using Cronbach's alpha. These values are greater than 0.78, which is in the acceptable range. Regression models are especially susceptible to multicollinearity. Thus, the potential for multicollinearity was diagnosed both before and after the model result generation. Before building the model, the Pearson correlation matrix was examined. Bivariate correlation coefficients in all the modes were below the absolute value of 0.65, which is consistent with the recommendation in Bettis-Outland et al (2012). After the model building and results generation, the Variance Inflation Factor (VIF) was used to check for evidence of multicollinearity. The common-off of VIF varies from 2-11 (Hair et al., 2010). The VIF results for the independent variables were below 10. Thus, taking the liberal view of VIF values, one can argue there was no evidence of multicollinearity in the predictive models.

## Results

The results of the data collection were analyzed statistically. To model the relationship between risks influencing ICT infrastructure and outturn costs, this research used multiple regression. This method of modeling is widely used in developing predictive models (Bettis-Outland et al., 2012; Boussabaine and Kirkham, 2005). The outturn cost due to ICT infrastructure risks was conceptualized in a general input/output relationship as follows:

$$Y = f(x)$$

Where x is the m-dimensional input (risks) and y is the n-dimensional real output (percentage of outturn cost). The above equation allows the ICT infrastructure risks to be mapped to project outturn cost. In this study, a Backwards regression procedure was used in SPSS to estimate the value of each of the regression coefficients. The method was selected because it is claimed it has "an advantage over the forward selection and stepwise regression" (Dallal, 2015).

Four models were devised to examine the influence of risks on outturn costs. The validity of the derived models was assessed through the normality of the residuals and P-P plots. For all of the models, the residual mean is found to be zero, which confirms the linearity assumption of the dataset and normality. The regression models are presented in Table II and interpreted in the following sections.

**Insert Table II about here**

***Planning & Development Risk predictors of outturn costs***

The first hypothesis was designed to examine whether Planning & Development Risk (PDO) can predict outturn costs (Table III). The output of the regression test is illustrated in Table II.

PDO risk predictive model was found to be significant, $F(12, 196) = 6268.006$, $p = 0.000$, $R^2 = .997$. The results also demonstrated that all 12 risk variables within the planning and development cluster have a statistically significant effect (i.e. $p < 0.05$) and are found to be good predictors for outturn cost. The highest Beta weight is associated with PD37, i.e. inadequate planning for migration from the old to the new system/network. The findings indicate that an increase in the planning and development risks might be associated with a significant rise in the outturn cost of ICT infrastructure projects. Moreover, the implication of this suggests that outturn costs can be controlled by identifying the variables within the PDO risk cluster and managing the variation associated with them. Higher efforts need to be directed towards variables that have higher coefficient values, such as inadequate planning for migration from old to a new system/network, as they contribute to higher variation in outturn cost.

**Insert Table III here**

***Technology and Hardware Risks predictors of outturn costs***

The second hypothesis was formulated to assess the contribution of technology/hardware risks to the prediction of the outturn cost of ICT network projects. The results showed that the simple correlation coefficient between THO and outturn cost is presented as.246, which is an indicator of a weak positive correlation between the two variables. Similarly, the $R^2$ was very low at 4%. Only 4% of the variation in the outturn cost can be explained by this model. However, the model THO was significant, $F (4, 204) = 3.272$, $p = 0.013$, $R^2 = 0.042$. Only one out of four – Technical complexity not understood – has a statistically significant effect on outturn cost at 95% confidence with the effect size (Beta) of.164. This confirms that technical complexity not being understood is a good predictor (under THO) of the outturn cost in ICT network projects. Thus, controlling the technical complexities in the projects through efforts might assist in reducing the cost of overruns.

***Operational Risk predictors of outturn costs***

The third research hypothesis was devised to assess whether operational risks have a significant influence on the outturn cost of ICT network projects. The pre-analysis result showed there was a high correlation (.860) to the dependent variable. Similarly, the $R^2$ was 74%, which is very high. The 26% variation which is not accounted for by the independent variable can be due to random variations or variation factors missing from the model. The OPO model 6 was significant, F (6, 202) = 95.598, p = .000, $R^2$ = .732). All OPO predictors were found to have a statistically significant effect on outturn cost. Based on these results, it can be argued that the outturn cost of ICT projects is significantly influenced by operational risks that arise from unstable networks, poor migration, testing failures, poor operational processes, and poor implementation. Developing a streamlined approach to managing and implementing operations can lead to the elimination or at least a reduction in operational risks, thereby improving the overall efficiency of the operations.

***People/Management Risk predictors of outturn cost***

The fourth hypothesis is conceived to discover whether or not people and management risks have a significant association with outturn costs in ICT network projects. Model $R^2$ was 75.5%, which is acceptable. The PMO model was statistically significant, F(9, 199) = 68.242, p = 0.000, $R^2$ =.744). As observed in Table II coefficients, PMO risk predictors have a statistically significant effect (i.e. $p < 0.05$) on the outturn cost. The highest Beta value corresponds to PM8 – i.e. Failure to manage staff priorities – followed by PM12 – i.e. Mismanagement of project schedule. It is not surprising to find that both failure to prioritize and mismanagement were more influential on outturn costs. It is well understood that managers who fail to manage project schedules also often fail to prioritize resource allocation. Thus, a better understanding of the work to be done and managerial skills and the ability traits to get the best from project staff are important in optimizing the outturn cost.

## Discussion

The result of the regression analysis confirmed that planning and development risks are significant predictors of outturn costs. Also, the results showed that Delayed approval has the most influential impact on outturn cost. Comparable results were reported by Anthopoulos et al. (2016), noting that understanding the project scope by the stakeholders allows for the determination of project cost and budget, thereby eliminating any delays in project-related approvals.

The second most influential risk is human resources mismanagement, which is inconsistent with past literature that examined the effect of HR management on outturn costs (Ab Razak and Zakaria, 2015; Weiss and Anderson, 2004). Similarly, the third most influential risk was noted as unsuitable system development lifecycle/process, which, as confirmed by Matavire et al. (2010) and Lappi et al (2019), can lead to additional ICT infrastructure projects expenditure.

The past literature assessing the influence of cost outcomes on ICT infrastructure projects and its association with technology and hardware risks has not studied the relationship from a statistical perspective but rather from a theoretical one (Taylor, 2015; Lappi et al., 2019). The result demonstrated that the use of unproven technology and technical complexity not understood are two likely predictors of outturn cost. Consistent with the observation of Skryabin et al. (2015) and Moktadir (2018), higher outturn costs are associated with firms' inability to utilize technology to its full potential. For successful development, installation, and operation of technology in ICT infrastructure projects, it is imperative to gather the right resources from the design stage that lead to effective implementation (De Cremer, 2017). Involving users right from the design stage can lead to lower technology and hardware bottlenecks, such as the inability of staff to apply the technology correctly, as evident from the past literature on technology and hardware risks (Nawi et al., 2011; Vaidya et al., 2018; Lappi, 2019). The findings in the current study indicate that an increase in technology and hardware risks can lead to a statistically significant increase in ICT infrastructure projects' cost burden.

Various factors contribute to operational risks, which include the effectiveness of ICT infrastructure, technology transition, technology testing, network instabilities, and service disruptions (Touray et al., 2013; Meijer, 2015; Bekkers and Thaens, 2005). This study adds to this list of factors and confirms the Instability of delivered network, Failure to properly migrate from old to a new network, Inadequate testing leads to operational failure of the network, and Failure to address the environmental impact on the network (harsh conditions, vermin damage, etc.) However, only four sub-variables. These findings are in line with Kaba et al. (2014), who found that technology implementation has economic and technical aspects for appraisal that strengthen its performance and lead to lower associated costs. Delays in ICT infrastructure projects, as confirmed by Qader, Hassan, and Saeed (2017), also lead to increased operational maintenance, which ultimately affects the overall outturn cost. The people and management risks in ICT infrastructure projects are found to be linked with the successful development, installation, and operation of ICT infrastructure network projects. Accountability for the ICT infrastructure projects' installation and operation rests with the people and management involved, thereby ensuring that the project objectives and goals are met (Lappi et al., 2019; Henriques et al., 2020). Past literature in this area highlighted that misalignment between ICT infrastructure projects, business communication and leads to poor ICT infrastructure project development and installation (Loukis et al., 2016; Bin-Abbas and Bakry, 2014; Balocco et al., 2013; De Vries, 2011; Lappi et al., 2019). The lack of ICT governance was also found to play a crucial role in poor ICT infrastructure development and installation, leading to misalignment of technology goals and organizational objectives, poor strategic direction, and implementation issues related to contracts issued and managed (Lappi et al., 2019; Henriques et al., 2020).

**Research Implication**

The findings from this research can be used by ICT infrastructure development stakeholders to enhance their understanding of the risks that may influence the outturn costs.  By mapping the risks to the development stages of the project, stakeholders will be able to have a more holistic view of all those risks which influence ICT infrastructure projects' outcomes. This will also enable them to plan effectively for mitigating and budget strategies. It is of benefit for stakeholders to not underestimate the complexity of ICT infrastructure projects. These types of projects require coordination not just amongst all the stakeholders but also between business processes, technology, and future infrastructure user requirements. This is necessary to make sure that the developed infrastructure can cope with future business requirements. It is also of paramount importance that stakeholders understand the risks that influence cost outturns so that can determine a risk-based project cost and budget, thereby minimizing the possibility of project failure. The findings would be of benefit to the government to develop policies and procedures to allow for the issuance of the essential regulation to expedite the development, implementation, and operation processes. Also, developers, consultants, contractors, and operators benefit from understanding the linkage between planning, development, operation risks, and outturn costs. They must appreciate the importance of various elements such as people, technology, and processes in optimizing the outturn costs. For cost-effectiveness, there is a need for interoperability and compatibility across all elements of an ICT infrastructure project. The results suggest that the stakeholders need to find innovative ways to properly manage risks to optimize outturn costs. For example, involving potential users, contractors, and technology providers may reduce the project stage can lead to lower technology and hardware bottlenecks and improved project scoping, leading to better cost-effectiveness and a reduction of project failure. Similarly, a mutual understanding of the project risks at the project scoping stage and sign-off on the project risk register might help in reducing project failure. Likewise, cost estimators and project finance analysts might use the risks to develop project costs and contingency plans. Equally, the findings would be of benefit to civil engineering firms and installation contractors to optimize their bids and develop an oversight of the risks that may influence the project's cost outturn. Finally, knowledge about the risk that influences project cost outturn could assist in augmenting the project success for all the stakeholders.

**Conclusion**

The theories of risk and cost overrun have been explored previously by academicians and researchers. However, they have not been inter-related, nor have they been discussed concerning ICT network projects. In light of the risk constructs' development, this study makes an important theoretical contribution. This study has developed a scale for measuring the risks that may influence ICT infrastructure projects' cost outcomes. This study applied univariate and multivariate analysis to assess the influence of risks on ICT infrastructure projects' cost outcomes. In doing so, the study identified the risks that have the greatest influence on project cost outcomes. Several predictors of outturn cost were identified: financial constraints, poor infrastructure, lack of compatibility and integration, lack of skilled personnel, poor data systems, leadership styles, culture and attitudes, technology and hardware, user needs and requirements, ICT Policy adoption, and operational issues. For this study, these risk factors were divided into four main categories: planning and development, people and management, operations, and technology and hardware. To deal with these risks, leaders or managers must participate in the project right from the beginning. The arguments of this study have implications for both practical application and theory. For professionals, this research provides guidelines and insights into the risks that may influence the cost outcomes of ICT infrastructure projects that are essential for IoT technology. The results of this study can be used to develop risk management for the development, installation, and operation of ICT infrastructure projects to mitigate project cost outcomes failure. This study has pointed out several challenges that may influence the cost of the potential development of ICT infrastructure to accommodate IoT technology. Thus, because of the importance of networks for the digital economy, there is an urgency to develop frameworks that address the risk issues identified by this study. This will enable stakeholders to manage the development and implementation of ICT networks robustly.

The study is based in the UAE and, therefore, the outcome is unique to the UAE. However, the identified risks can serve as a basis for conducting research elsewhere. Future studies may draw on some of the findings in this work to develop a risk framework for IoT development, installation, and operation. For a clearer understanding of the dependency between risk and cost outcomes, it would be worthwhile for future research to investigate the interaction between risks, cost, risk management, and technological innovations in ICT infrastructure projects to accommodate IoT technology.

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**Table I: Risk factors list from literature**

| Risk indicators | Source |
|---|---|
| **1. Risks Sources for Planning and Development Risk Factors** | |
| Project scope not understood | Nawi, Rahman and Ibrahim (2012)<br>Elzamly and Hussin, (2015)<br>Dutta and Coury (2002)<br>Lappi et al (2019)<br>Anthopoulos et al (2016)<br>Sherwood (2005)<br>Adomi (2010)<br>Hutton (2019) |
| Business requirements not understood | |
| Missing or inadequate project charter/project initiation document | |
| Inadequate management of or missing business case | |
| Failure to align project scope with organization or business strategy | |
| Initial current state not understood | |
| Budget not adequately estimated or planned | |
| Budget not provided or budget withdrawn | |
| Risks not properly analyzed or mitigated | |
| Unrealistic schedule at start of project | |
| Unclear project responsibilities | |
| Contractual or legal risk not understood | |
| Technical risks not analyzed or mitigated | |
| Unsuitable system development lifecycle/process | |
| Inadequate project planning | |
| Inadequate resource planning | |
| Inadequate project communication plan | |
| Testing not planned properly | |
| Project rejected because of inadequate business continuity planning | |
| Unable to secure an implementation partner | |
| Stakeholders mismanaged or not identified | |
| Contractors/vendors mismanaged | |
| Plan rejected by business | |
| Inadequate understanding of project benefits | |
| Changes to business requirements during the project | |
| Changes to scope during the project | |
| Quality mismanaged | |
| Human resource mismanaged | |
| Procurement mismanaged | |
| Time/schedule mismanaged | |
| Delayed on approval | |
| Inadequate project management | |
| Insufficient human and financial resources | |
| Inadequate management of project development lifecycle/process | |
| Delays in external approvals or decision making | |

| | |
|---|---|
| Inadequate testing | |
| Inadequate planning for migration from old to new system/network | |
| Training not planned or conducted adequately | |
| **2. Risks Sources for Technology and Hardware Risk Factors** | |
| Failure to address integration of components within the project | Warren, Davies and Brown (2008) Bouwman, Van Den Hooff and Van De Wijngaert (2005) Mahendra et al. (2014) Lappi et al (2019) Anthopoulos et al (2016) Hutton (2019) Moktadir (2018) De Cremer et al (2017) Wong and Kim (2017) |
| Failure to address integration with existing technology | |
| Inadequate or incorrect design | |
| Incompatibility of new with existing technology | |
| Information security not properly addressed or understood | |
| Technical complexity not understood | |
| Technology not meeting the business requirements | |
| Use of unproven technology | |
| Inadequate or missing development tools or environment | |
| No support from manufacturer | |
| Technical failures caused by quality mismanagement | |
| Unexpected technology failures | |
| Technology failures caused by unstable project team | |
| Failure to provide supporting infrastructure on time (e.g. power) | |
| Failure to take account of operating conditions (harsh physical environment) | |
| **3. Risks Sources for Operational Risk Factors** | |
| Operational problems caused by poor implementation | Leydesdorff and Wijsman (2007) Satapathy et al. (2014) Leydesdorff and Wijsman (2007) Anthopoulos et al (2016) Moktadir (2018) Lappi et al (2019) Hutton (2019) Wong, et al (2017) Meijer (2015) |
| Instability of delivered network | |
| Inadequate budgeting for maintenance and support | |
| Inadequate requirements management leading to operational failure of the network | |
| Inadequate design leading to operational failure of the network | |
| Failure to properly migrate from old to new network | |
| Inadequate training leading to operational failure of the network | |
| Inadequate testing leading to operational failure of the network | |
| Market development pace rendering products obsolete | |
| Changes to business requirements after network delivery | |
| Inadequate monitoring of the network/system | |
| Changes in operation process and policy | |
| Poor management of third parties necessary for network operation | |
| Failure of third parties to deliver necessary services for network operation | |
| Organizational changes leading to operational problems | |

| | |
|---|---|
| Inadequate change control after delivery | |
| Inadequate operational processes | |
| Failure to address environmental impact on network (harsh conditions, vermin damage etc.) | |
| **4. Risks Sources for People and Management Risk Factors** | |
| Failure to achieve compatibility with the strategic business direction of the organization | Mueller-Jacobs and Tuckwell (2012)<br>National Research Council (2000)<br>Anthopoulos et al (2016)<br>Lappi et al (2019)<br>Loukis et al. (2016)<br>Moktadir (2018)<br>Henriques et al (2020)<br>Hutton (2019) |
| Failure to comply with legislative requirements, such as finance regulations | |
| Misalignment of the project with organization's standards and policies | |
| Mismanagement of scope and requirement changes during the project | |
| Contractual issues | |
| Failure to ensure project staff have the necessary skills | |
| Failure to manage confidentiality (information disclosure) | |
| Failure to manage staff priorities | |
| Failure to manage the budget | |
| Failure to provide enough project staff at the required time | |
| Inadequate management of budget needed for staff | |
| Mismanagement of project schedule | |
| Failure to achieve compatibility with the organization's IT strategic direction | |
| Organizational changes not properly managed | |
| Failure to manage and deliver necessary training | |
| Inadequate management of budget needed for training and support | |
| Inadequate management of changes to operational processes and policies | |
| Issues caused by external agencies on which the project depends | |

**Table II: Final regression models summary**

| PDO Model | | | THO Model | | | OP Model | | | PMO Model | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $F(12, 196) = 6268.006$, $p = 0.000$, $R^2 = .997$ | | | $F (4, 204) = 3.272$, $p = 0.013$, $R^2 = 0.042$ | | | $F (6, 202) = 95.598$, $p = .000$, $R^2 = .732$ | | | $F(9, 199) = 68.242$, $p = 0.000$, $R^2 =.744$ | | |
| Predictor | β | Sig | Predictor | β | Sig | Predictor | β | Sig | Predictor | β | Sig |
| (Constant) | 3.003 | 000 | (Constant) | 3.051 | .000 | (Constant) | -.606 | .284 | (Constant) | 9.703 | .000 |
| PD2 | .142 | 000 | TH1 | .092 | .174 | OP18 | .733 | .000 | PM5 | 1.360 | .000 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PD7 | .557 | 000 | TH2 | .125 | .274 | OP2 | 2.644 | .000 | PM8 | .871 | .000 |
| PD8 | .184 | 000 | TH6 | .164 | .047 | OP6 | 1.029 | .000 | PM10 | .522 | .000 |
| PD11 | .801 | 000 | TH8 | .183 | .052 | OP8 | .614 | .000 | PM1 | 1.217 | .000 |
| PD15 | .222 | 000 | | | | OP17 | .366 | .000 | PM16 | .508 | .000 |
| PD22 | .503 | 000 | | | | OP1 | .210 | .000 | PM14 | 2.682 | .000 |
| PD24 | .176 | 000 | | | | | | | PM18 | .653 | .000 |
| PD31 | 2.46 | 000 | | | | | | | PM12 | .673 | .000 |
| PD34 | .900 | 000 | | | | | | | PM9 | .378 | .000 |
| PD35 | .242 | 000 | | | | | | | | | |
| PD37 | 3.044 | 000 | | | | | | | | | |
| PD38 | .442 | 000 | | | | | | | | | |

**Table III: The results of the regression analysis confirmed hypotheses**

| **Hypothesis** | **Testing outcome** | **P value**<br>**p <0.05** |
|---|---|---|
| H1. Planning and Development risks have a significant influence on ICT network project outturn cost | **Hypothesis supported for risks related to planning and development**<br>Business Requirements not understood<br>Budget not adequately estimated or planned<br>Budget not provided or budget withdrawn<br>Unclear project responsibilities<br>Inadequate project planning<br>Contractors/vendors mismanaged<br>Inadequate understanding of project benefits<br>Human resource mismanaged<br>Delayed on approval<br>Inadequate management of project development lifecycle/process<br>Delays in external approvals or decision making | *Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted* |

| | | |
|---|---|---|
| | Inadequate planning for migration from old to new system/network<br>Training not planned or conducted adequately | |
| H2. Technology/Hardware risks have a significant influence on the outturn cost in ICT network projects | **Hypothesis supported for risks related to technology and hardware**<br>Failure to address integration of components within the project<br>Failure to address integration with existing technology<br>Technical complexity not understood<br>Use of unproven technology | *Rejected*<br>*Rejected*<br>*Accept*<br>*Partial* |
| H3. Operational risks have a significant influence on outturn cost ICT network projects | **Hypothesis supported for risks related to operations**<br>Operational problems caused by poor implementation<br>Instability of delivered network<br>Inadequate requirements management leading to operational failure of the network<br>Failure to properly migrate from old to new network<br>Inadequate training leading to operational failure of the network<br>Inadequate testing leading to operational failure of the network<br>Organizational changes leading to operational problems<br>Inadequate operational processes<br>Failure to address environmental impact on network (harsh conditions, vermin damage etc.) | *Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted* |
| H4. People / Management risks have a significant influence on outturn cost of ICT network projects | **Hypothesis Supported for risks related to people and management**<br>Failure to achieve compatibility with the strategic business direction of the organization<br>Contractual issues<br>Failure to manage staff priorities<br>Failure to manage the budget<br>Failure to provide enough project staff at the required time<br>Mismanagement of project schedule<br>Organizational changes not properly managed | *Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted*<br>*Accepted* |

| | | |
|---|---|---|
| | Inadequate management of budget needed for training and support<br>Issues caused by external agencies, on which the project depends | |

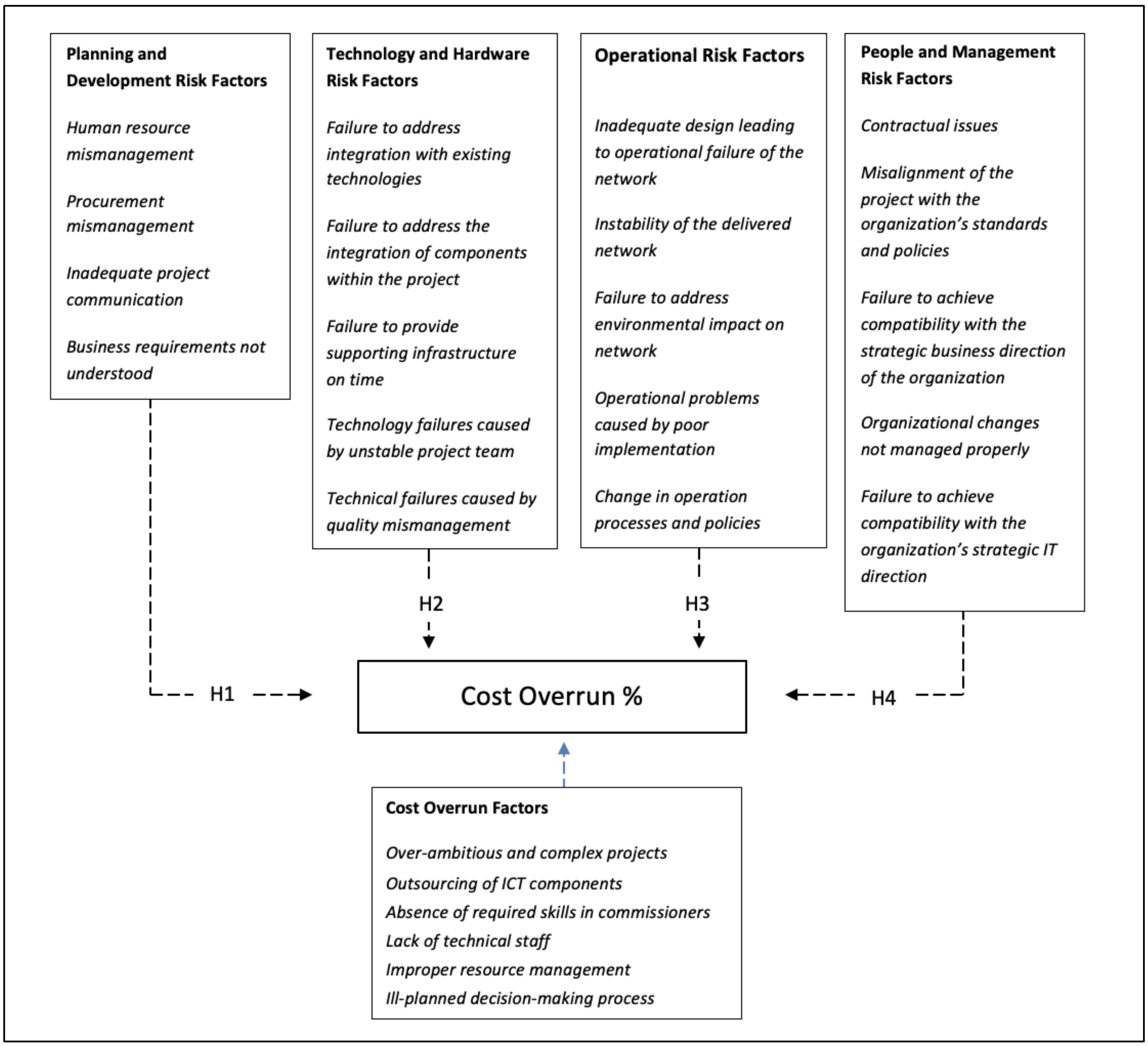


**Figure 1: Conceptual Framework for ICT Implementation in the UAE**