Critical success factors for public-private partnerships in smart city infrastructure projects

Khalid Almarri and Halim Boussabaine
Faculty of Business and Law, The British University in Dubai, Dubai, United Arab Emirates

To cite this article: Almarri, K., & Boussabaine, H. (2023). Critical success factors for public–private partnerships in smart city infrastructure projects. *Construction Innovation*. DOI: https://doi.org/10.1108/CI-04-2022-0072

Abstract

Purpose- Scaling up smart city infrastructure projects will require a large financial investment. Utilizing public-private partnerships is one of the most effective ways to address budget constraints. Numerous factors have varying degrees of influence on the performance of PPP projects; certain PPP factors are more crucial to the success of a smart city infrastructure project than others, and their influence can be greatly increased when they are fulfilled collectively. The aim of this study is to find out what factors are unique to smart city PPP initiatives, as well as how these factors work together, so that successful smart city infrastructure PPP projects can be scaled up.
Methodology- The methodology included three sequential stages: identifying the CSF of PPP for smart cities based on an extensive literature review, collecting data from a sample of 90 PPP practitioners using a Likert scale questionnaire, and estimating interrelationships among the CSF and their emergent clusters using structural equation modelling (SEM).
Findings- The best fit model developed in this study demonstrated the significance of each factor and their interrelationships within their categories in enhancing the performance of PPPs in smart city infrastructure projects. Five categories of critical success factors for PPPs in smart city infrastructure projects have been established: partnership and collaboration, financial sustainability, contractual duties and outsourcing, smart integration, and contract governance.
Implications- The proposed model represented the causal interrelationships among relevant critical success factors derived from literature, which may help in directing the organization's attention and resources to more critical areas, leading to the effective fulfilment of the smart city infrastructure project's objectives. In addition to the theoretical and methodological contributions, this study produced a usable and readily adaptable list and clusters of critical success factors for research in the area of the implementation of PPP in smart city infrastructure projects.
Originality/ value- This is the first study to identify PPP critical success factors and their themed clusters for smart city infrastructure projects.

Keywords: Smart procurements, public procurements, PPP, critical success factors, smart city infrastructure projects

1. Introduction

Numerous smart cities have started to appear throughout the world as a result of growing urbanization and the development of information and communication technologies (Lam and Yang, 2020). According to Lam and Yang (2020), the market potential for smart cities would approach $2 trillion by 2025. The funding necessary to scale up smart city initiatives is frequently large, placing a burden on government resources, as Fishman and Flynn (2018) noted, with only 16% of cities can self-fund vital infrastructure. Most governments would investigate the idea of involving the private sector in the development of smart cities (Selim & ElGohary, 2020). Smart cities are relatively new arenas for investment decision-making. When deciding whether or not to implement PPP in general, it is a large-scale tactical decision (Tran, Dupont & Camargo, 2019).-PPP initiatives frequently try to harness the private sector's knowledge and resources to assist in the operation of public services, delivering the benefits of enhanced innovation, efficiency, and quality with better funding (Osei-Kyei and Chan, 2015).

The PPP arrangements often include the private actor absorbing the initial financing cost in exchange for the public actor paying a leasing charge throughout the life of the contract, such as the Private Finance Initiative in the United Kingdom in the 1990s (Broadbent et al., 2003; Pianezzi, et al., 2021). However, these projects revealed various flaws, including a loss of political authority, responsibility dispersion, improper risk assessment, and a collision of ethos between public and private contractors (Broadbent et al., 2003; Pianezzi, et al., 2021). Significant obstacles as well may arise owing to complicated decision making, inadequate risk management, insufficient transparency, and a lack of market competition, since participation may be confined to large players from the private sector (Jayasena et al., 2020).

Various PPP mechanisms have been employed for smart city infrastructure across the world, with varying degrees of success (Jayasena et al., 2020). The main distinctions between standard PPPs and those to be used in infrastructure projects for smart cities are the high risk of investing in innovative solutions, the unpredictability of policy, and the length of time until profitability. As a result, the key challenges to implementing PPP in smart city development may be summarised as difficult decision-making, industry uncertainty, policy uncertainty, inadequate risk management, low transparency, and a lack of information (Jayasena et al., 2020). Furthermore, finding suitable partners for smart city initiatives might be highlighted as another barrier (Sandulli et al., 2017). According to recent research, the transactional nature of PPPs may be unsuitable for addressing the special issues that characterize collaboration in smart city initiatives (Liu et al., 2020). These necessitate significant expenditures in technology innovation, complicating risk-sharing relationships between public and private entities even more (Liu et al., 2020).

Furthermore, the creation of a smart city projects requires a high degree of innovation, which necessitates significant economic and business creativity on the part of service providers (Ojasalo and Kauppinen, 2016). Governments may overcome problems in funding and administering smart city initiatives by the introduction of future technology to cut costs, salvaging current and legacy infrastructure assets, unlocking value, and bringing important vital actors together (Liu et al., 2020). As a result, collaborations are required to progress smart city projects. PPPs are a collaborative concept that allows the public and private sectors to work together to construct smart city initiatives (Liu et al., 2020). PPP project performance is influenced by a variety of factors, some of which are critical to the project's success. The critical success factors are the key prerequisites to the success of any PPP project and identifying and rating them in order of significance aids in adhering to the contexts in which the projects are being produced. CSFs also assist in focusing the organization's attention and resources on more essential areas, resulting in the successful achievement of the objectives (Gupta et al., 2013). The approach focuses on areas where positive outcomes are crucial for the organization to fulfil its goals in a timely and efficient manner.

Despite the fact that various studies have been undertaken to demonstrate the effectiveness of PPP applications (Ismail, 2013; Li, Akintoye, Edwards, & Hardcastle, 2005; Yuan, Zeng, Skibniewski, & Li, 2009), the underlying trend in the available literature on the critical success factors criteria emphasizes the importance and ranking of individual success factors for generic construction projects. Lam and Yang (2020) emphasized that non-generic projects, such as smart cities, should be treated cautiously by introducing additional success criteria. The effective deployment of PPPs in most nations is due to constant evaluation and study of the prevailing critical success factors for PPP projects in these countries (Osei-Kyei and Chan, 2016). This indicates that certain critical conditions must be met before PPP may be implemented in a country (Osei-Kyei and Chan, 2016).

The rationale for this study is that in order to scale up smart city initiatives, public-private partnerships are essential for addressing the financial and technological issues associated with these projects and ensuring that these programs satisfy economic and social objectives. This study will also add to the theoretical knowledge of the theories that underpin Rockart's model by increasing their contributions in a novel way through the formation of interrelated factors and clusters. Furthermore, the identified clusters may be investigated for categorical influences in future studies.

The aim of this study is to establish the PPP critical success factors in smart city infrastructure projects and to empirically assess and create a structural equation model of the interactions between the CSFs' latent variables. This statistical approach assesses and estimates the strength of causal relationships by combining data with qualitative causal assumptions, which are derived from theories. The model would represent the causal interrelationships between the CSF components, which may aid in the implementation of appropriate procedures and investment strategies to ensure the success of PPP arrangements for smart city infrastructure projects.

The primary motivations for using PPPs are to provide access to private finance and to enable the implementation of projects that would not be feasible otherwise, as well as to take advantage of the private sector's perceived higher efficiency in delivering public services (Liu et al., 2014). The CSFs are crucial to the success of any process and identifying and assessing them based on their relevance in delivering value supports practitioners in adhering to the contexts in which projects are developed. To establish the most critical success factors and their relationships with one another in order to ensure the success of PPPs in smart city infrastructure projects, the established factors from the literature, as well as their theoretical relationships, must be empirically tested in order to accomplish the study's objective and make a significant contribution to researchers and practitioners alike. Structural equation modeling is the optimal method for validating such theoretical assumptions in this case (Xiong et al., 2015). SEM is a multivariate approach for simultaneously estimating a collection of related dependent relationships. SEM is thought to be an extension of standardized regression modelling, and it is often employed to deal with poorly specified independent variables (Hair et al., 2010). This technique is combined with literature and theory-based models that are described by the researcher first, followed by a fitness evaluation of the data against those models (Manhas et al., 2013).

This work is divided into five sections. Section 2 provides context as well as a critical analysis of current research in order to update the current CSF to match the requirements of smart city infrastructure initiatives. Section 3 discusses the methodology used to arrive at the results. Section 4 contains the data analysis, as well as a discussion of the findings and their implications. Section 5 is the conclusion, where the results of the study will be summarized in connection to the objectives, in addition to highlighting the originality, contributions, and future research suggestions.

2. Literature review

2.1 Smart cities and infrastructure

The term "smart city" refers to the intelligent and coordinated use of all available technology and resources to construct urban centres that are linked, habitable, and sustainable all at the same time (UNCTAD, 2016). Whereas smart infrastructure "provides the foundation for all of the key themes related to a smart city, including smart people, smart mobility, smart economy, smart living, smart governance, and smart environment" (UNCTAD, 2016). "Smart infrastructure can be divided into two actual parts which are 'the `physical smart infrastructure' and 'the digital smart infrastructure" (Selim & ElGohary, 2020).

During the previous decade, the notion of the smart city evolved as a fusion of concepts about how ICT may enhance the running of cities by increasing their efficiency, boosting their competitiveness, and creating new solutions to address issues of poverty, social deprivation, and bad environmental conditions (Harrison et al., 2010). Smart cities increase quality of life, employment, and investment prospects by focusing on the environment, social sustainability, and competitiveness. Institutional, physical, and social infrastructures have been identified as the three pillars necessary to accomplish the government's goal of smart cities (Amirullah, 2016). The fundamental aspect that drives the bulk of these components is that they are interconnected and provide data that can be used intelligently to ensure optimal resource use and performance.

In today's economic environment, infrastructure developers face difficulties in achieving the required level of performance while staying within a specific budget, on top of the complexities and high investment costs of smart city infrastructure projects (Selim & ElGohary, 2020). PPP is one of the suggested and viable techniques for tackling the financing and technological challenges of smart city infrastructure projects, as well as one of the UN's main tools for sustainable developments (Selim & ElGohary, 2020). PPPs are agreements between groups of stakeholders from the government (public sector) and the private sector (private sector) to share finances, risks, experience and expected returns in infrastructure projects (Alfen, 2010).

2.2 Public private partnerships

In the United Kingdom, the word PPP refers to a range of various types of public-private sector collaboration. PFIs, which were introduced in 1992, are design-build-finance-operate projects that are organised as a purchase of continuing services by the public sector (Broadbent and Laughlin, 2004). The UK government introduced the PF2 model in 2012, which broadly mirrored the PFI model but included a number of adjustments intended to boost transparency, promote efficiency, assure value for money, and stimulate funding from alternative sources (Marshall et al., 2022). Changing political emotions have had a significant impact on the use of PFI/PF2 throughout the years. PFI/PF2 were no longer utilised to provide new infrastructure in the UK in 2018, although other PPP models are being employed, and the government has announced that it would investigate new private finance models as well as how current PPP models might be implemented in new sectors (Marshall et al., 2022).

PPP initiatives have the potential to share risk while introducing private-sector innovation and experience (Malek and Gundaliya, 2021). These kinds of projects frequently make better use of funds (Alfen, 2010). Scholars are drawn to several features of PPP projects, including their long durations, large number of partners, complex procedures, and high risks. Many studies have been conducted to analyse the PPP model on a systemic level in order to assess the effectiveness of these initiatives (Malek and Gundaliya, 2021; Lam and Yang, 2020; Jayasena et al., 2020). Some academics have also examined these studies and discovered that they are experiencing significant transformations (Lam and Yang, 2020; Jayasena et al., 2020).

While public-private partnerships provide several advantages in the development of built infrastructure, major impediments may occur as a result of complex decision-making, inefficient risk management, a lack of transparency, and a lack of market competition (Jayasena et al., 2020; Kwak et al., 2009). The delivery and operation of smart city projects necessitates the collection and processing of large amounts of data. When engaging the public, information security concerns arise as a result of the collection and analysis of citizens' personal, commercial, and municipal data. Furthermore, smart city projects typically include a high level of innovation and intelligent solutions, sustainability goals, and technical collaboration with local universities or research centres (Selim et al., 2018). Therefore, traditional contract-based PPP models may not be appropriate for smart city initiatives (Liu et al., 2020). Diverse PPP approaches have been used to develop smart city infrastructure projects globally, with varying degrees of success. As Jayasena et al. (2020) noted, a variety of challenges have occurred when various PPP models have been implemented. In developing countries, a lack of information and knowledge in the private sector has been recognized as a barrier to PPP adoption (Jayasena et al., 2020; Sharma and Bindal, 2014). According to De Oliveira and Pinhanez (2017), barriers to PPP adoption in smart city infrastructure projects include the high risk involved with investing in new solutions, legislative uncertainty, and lengthy time horizons for profitability.

Variations in PPP models are also important to account for the characteristics of smart city infrastructure projects, according to Jayasena et al. (2020), Lam and Yang (2019), and Nguyen et al. (2019). As a result, it is argued that there are barriers to PPP adoption in smart city infrastructure projects, which may be solved by identifying the drivers of PPP benefit realization in smart city infrastructure projects (Jayasena et al., 2020).

There are several examples of PPPs being used in smart city developments, and several nations are adopting distinct PPP models to fit their specific settings (Jayasena et al., 2020; Fu, 2018; Li et al., 2015). More research studies on smart cities have been conducted mostly in developed countries, whereas new technologies are seen in developing countries. According to Vu and Hartley (2018), cities in developing countries are rapidly adopting pilot projects to test a variety of applications, ranging from traffic and waste management systems to e-governance and public engagement, which are required for smart city growth. PPPs are employed in both developed and developing nations, with the private sector increasingly involved in the supply of public infrastructure development (Jayasena et al., 2020; Levin & Tadelis, 2010).

Therefore, it is vital to identify the critical challenges faced in the adoption of PPP in smart city infrastructure projects in both developed and developing countries. And, as one of the few attempts to identify the CSF for PPPs in smart city infrastructure projects, and for it to have a wider impact, this study incorporates a sample of practitioners and researchers from both developed and developing countries, drawn from the United Kingdom and the United Arab Emirates.

The CSFs are described as the few important areas of activity where favourable results are considered necessary for a management to meet the objectives (Li et al., 2005). Rockart's critical success factor categorization is frequently utilized in the literature, notably in public–private partnership research (Liu, Love, Davis, Smith, & Regan, 2014; Medeiros, Perez, & Lex, 2014). Critical success factors are characterized by Rockart as industrial (industry features), environmental (economy, competitiveness, infrastructure), strategic (stakeholder objectives), and temporal (internal pressures, impediments) (Jefferies et al., 2002). These elements may be investigated together or individually to determine the causative, contextual, and intervening impacts, as well as how they contribute to the success of PPP initiatives.

A systematic review of relevant published literature was conducted in order to determine the CSFs of PPP, both for general and smart city infrastructure projects. The study used a systematic literature review technique to perform a thorough and in-depth evaluation of the existing research and conclusions on this subject. Systematic literature reviews are useful for investigating the gaps and potential research issues in an area of study by directing searches in the discovery of major themes, methodologies, and findings (Jayasena et al., 2020 ; Yigitcanlar et al., 2019). Finding pertinent research papers was the first step in this process. The search terms chosen were "Smart City," "Smart Infrastructure," "critical success factors" and "Public-Private Partnership." Using all of the search terms combined, the researcher looked for research publications in Google Scholar. This research was mainly restricted to reviewing academic articles from 2005 to 2022 in order to capture the advances of PPP and smart cities. The examination of these pieces of literature yielded the identification of 18 major PPP CSFs that can be used in the context of smart city infrastructure projects (Table 1). These 18 factors will be the foundation for the hypothesized model that will be tested and improved by SEM.

Insert Table 1 here

3. Methodology

Structural equation modelling (SEM) was chosen as the method for this study. SEM is a useful tool for tackling substantive problems in social science by determining how well a hypothesised model fits the observed data, as it is used to find speculative cause and effect relationships (Hatcher & O'Rourke, 2013).

One of the key assumptions of structural equation modelling is that all constructs must be represented in the model based on measurement theory (Aguirre-Urreta et al., 2016). In this study, covariance-based SEM was chosen over partial least squares SEM for testing the hypothesized model. CB-SEM is frequently used to operationalize measurement theory in most research. In this measurement paradigm, indicator loadings are investigated first. PLS-SEM is inconsistent in its appraisal of measurement models. Another benefit of CB-SEM is that it detects multicollinearity in the model, whereas PLS-SEM is significantly more biased than CB-SEM in different cases (Afthanorhan et al., 2020).

Each variable in this technique has a large number of indications that are integrated to generate a single instrument. The majority of instruments used in social science research are capable of measuring error; this error is caused by disparities between the studied population and the sample (Bryman, 2008). SEM is a statistical technique that enables the researcher to reduce the measurement error to a level that is acceptable. SEM was described by Schreiber (2008) as a confirmatory approach that may also be used for exploratory reasons. As a result, this study follows Schreiber (2008) in determining the validity of the hypothesized model. Additionally, SEM studies include an exploratory component, in this case examining the link between PPP critical success factors and smart city infrastructure projects' success. After estimating the model's parameters, the result model's indicated covariance matrix is compared to the empirical covariance matrix. If the two matrices are consistent, the SEM is regarded as a reasonable explanation for the observed relationships between the research variables; this can enhance the study's overall credibility. As a result, structural equation modelling was chosen as the analytical method for this study.

SEM development typically involves the following stages: (1) identify and define (operationally) model components (which may include latent variables, measured variables, and any other variables) based on theory; (2) construct a hypothetical model (model specification), which may occasionally involve the construction of multiple models (competing models) depending on the theoretical foundations and purpose of the research; and (3) determine the model's validity by assessing the model’s Chi square, estimates and goodness-of-fit indices (RMSEA, CFI, and TLI) using data obtained based on the model's operationalized components (variables); and (4) identify potential model adjustments and amend the model with theoretical reason. (Molwus et al., 2017).

Survey research is a very prevalent method of study in the social sciences and education (Muijs, 2004). This is mostly because it is an efficient method for gathering large amounts of data, and it is also flexible in that it can be used to investigate a wide range of topics. (Muijs, 2004). Furthermore, response rates, validity, and reliability of questions may be improved through questionnaire design and clear layout (Saunders et al., 2016). Due to the nature of the research, which was both descriptive and explanatory, questionnaires were used to get the data for the research.

The survey questionnaires were formatted using pertinent elements of the template questionnaire provided by Li et al (2005). Li’s template was divided into sections for assessing the attractive factors, value for money elements, and critical success factors for PPP/PFI projects in the United Kingdom. Many factors influenced the decision to choose Li et al’s (2005) template. First, this template and its contents are well known and quoted in the PPP research (Olanike, et al., 2021; Chou & Pramudawardhani, 2015; Hwang et al., 2013; Osei-Kyei & Chan, 2015; Robert et al., 2014). Second, using an existing valuable resource rather than inventing a new one will save time, allowing more time to be focused on the study of the data. Finally, Li et al’s (2005) template was created in the UK construction sector and it matches the UAE's construction regulations.

The format was later modified to include the new factors that were established for smart city infrastructure projects in the literature review section and summarized in Table 1.

A five-point Likert scale questionnaire was used to collect the opinions of a diverse group of practitioners involved in smart city PPPs. Survey item scores are a frequently used input for SEM analysis because they give a matrix of covariances for measurable variables (Manhas et al., 2013). 90 qualifying questionnaires were returned from PPP professionals with varied levels of experience in smart city programs in the UAE and the United Kingdom, ensuring a balance of developed and developing countries. A minimum sample size of 50 and a maximum sample size of 100 may be sufficient for SEM analysis to produce accurate findings (Molwus et al., 2017). The questionnaire was administered online, concurrently in the United Kingdom and the United Arab Emirates. Participants for the questionnaire were chosen using criteria that included practitioners from both the public and private sectors, as well as PPP scholars. Experience with PPPs in the UAE and PFI/PPP in the UK was required. Participation in the development of smart cities was also required. The sampling criteria used in this study were convenient sampling. The rationale for this decision was that it was difficult to enter the pool of respondents in the United Kingdom, and recommendations were the only way to reach qualified respondents. Additionally, the pool of respondents was quite small in the UAE, and the demographics from which the sample was drawn were unclear. This hindered the utilization of random sampling to ensure that the sample was representative of the population (Ellsberg et al., 2005).

The questionnaire data was analysed. Incomplete surveys were excluded from the study, negative questions were corrected, missing values were restored, data were coded, and Cronbach Alpha was used to determine data reliability. The hypothetical CSFs for PPPs in smart city infrastructure projects model was empirically tested using IBM SPSS AMOS software. To do this, it was investigated whether the relationships between the observable and latent variables were suitable and significant as well as whether there were any correlations or covariances between the latent variables (Molwus et al., 2017). In total, 52.2% of the participants in this study worked in the private sector, 29.3% worked in the public sector, and 18.5% were identified as researchers. In terms of organizational structure, 30.4% of respondents were identified as top managers, 47.8% as middle managers, and 21.8% as general employees. In terms of experience, 8.7 % had less than six years, 22.8 % had between six and ten years, 48.9 % had between eleven and twenty years, and 19.6 % had more than twenty years.

The principal component analysis demonstrated the presence of more than one factor in each group, indicating that data commonality was not an issue (Hair et al., 2010). Cronbach's alpha coefficient for the measured variables was 0.904. Cronbach's alpha is a widely used test that accurately measures the internal consistency of a study's measurement set, showing a high degree of reliability (Hair et al., 2010).

Nonetheless, two tests must be performed prior to doing the EFA. Kaiser-Meyer-Olkin (KMO) test is used to determine sample adequacy, while Bartlett's test is used to determine sphericity (Hair et al., 2010). KMO and Bartlett's tests yield acceptable values greater than 0.5 and $p < 0.001$, but should be less than the threshold ($p = 0.05$), suggesting that the correlation matrix is not similar to the identity matrix (Hair et al., 2010).

The KMO test for sampling adequacy returned a result of 0.824, indicating that the sample is factorable (Brace et al., 2012). The Bartlett's Test of Sphericity was high (Chi-Square = 786.1, significance = 0.000), suggesting that the correlation matrix is unlikely to be an identity matrix and confirming that no component has to be eliminated (Brace et al., 2012). Exploratory factor analysis (EFA) is required to determine the number of latent variables that may be retrieved from theoretically established measurement items, which should match the conceptual model being validated by the investigation (Hair et al., 2010). To calculate the EFA, the data was analysed using principal component analysis, with factor grouping using a Varimax rotation to get the total variance explained by each factor. When the Eigenvalue was more than one, six components were determined to be sufficient to reflect the critical success factors for PPPs in smart city infrastructure projects (Brace et al., 2012). The next step was to find the best model to account for all of these variables. Structural equation modelling (SEM) was used (Figure 1).

The first cluster in the redesigned model (partnership and collaboration) consisted of SF1-sharing of risk and authority, SF2- commitment of parties and coordination with other departments, SF3- competence of public agency, SF12- political stability, SF15- social support and citizen participation. The relevance of each factor's power and interrelationships with other elements within the cluster dominate this cluster. Partnership has frequently been emphasized as an important component of project outsourcing. Partnership can reduce the risk of insufficient contractual provisions, which can be comforting for stakeholders who view outsourcing as a difficult and expensive activity. Collaboration across various functional sectors and players (government, business, academia, non-profit and volunteer groups, and others) helps municipal initiatives succeed (Broccardo et al., 2019).

Four items loaded on cluster two (financial sustainability): SF5-Clear project brief and performance measurements, SF9-Finance and asset availability, SF10-Macro-economic conditions, SF16-Economic sustainability. The modified model produced a financial sustainability cluster that included four interrelated important success variables for smart city infrastructure projects: financing and asset availability and economic sustainability. They directly contribute to the financial viability of the smart city PPP project. Financial sustainability refers to a government's capacity to satisfy its financial and service responsibilities in a systematic manner, despite the fact that public finances are entrenched within complex economic, political, and social settings. It also indicates a government's capacity to engage with the complex environment in order to satisfy current and future financial commitments and ensure successful smart city infrastructure projects delivery (Gabriel and Garcia ,2022).

Two items loaded on cluster three (contractual obligations and outsourcing cluster): SF6-Legal framework and regulations, SF7-Shared authority and resources between public and private parties. An effective and adaptable dispute resolution process should be established to aid in ensuring contractual obligations and the stability of PPP arrangements in smart city infrastructure projects. An outsourcing contract creates a legally binding, institutional framework in which each party's rights, obligations, and responsibilities are documented.

Two items loaded on cluster four (smart integration): SF17-Availability of expertise and data, SF18-Integration with other smart city initiatives. The development of smart city infrastructure projects makes use of a vast amount of data derived from citizen behaviour. Given that it may be used to provide information on asset performance and optimization, this data is essential for smart cities (Liu et al., 2020). Additionally, this will make it possible to include smart city infrastructure projects into all phases of the PPP lifecycle, leading to long-term smart governance and the standardization of project requirements. This would guarantee that all smart city efforts are incorporated into the long-term policy of the government.

Two items loaded on cluster 5 (procurement of innovation): SF13-Transparent procurement process, SF14-Technological innovation and rate of diffusion. Through procurement, the public sector may persuade private enterprises to make greater investments in innovation, assist them in bridging the gap between development and commercialization, and promote the diffusion of innovation (Pihlajamaa & Merisalo, 2021).. Public procurement of innovation is seen to have the ability to better meet the procurement demands of public organisations than current solutions and to have broader societal advantages (Uyarra et al. 2020).

Finally, two items loaded on cluster six (supportive environment): SF8-Government guarantees, and SF11-Multi-benefit objectives of all stakeholders. A favourable institutional and regulatory setting is facilitated by a supportive environment. Governments in developing nations must concentrate on creating not just a regulatory environment but also a favourable environment for the ecosystem's important players in order to construct inclusive smart cities (Kummitha & Crutzen, 2019). (Table 2)

Insert Table 2 here

In the new model the minimum was achieved where Chi-square was insignificant at 0.082 with a value of 70.129 (degrees of freedom=55) which indicated that the model has a good fit. The model suggested significant regression paths as shown in Figure 1.

Insert Figure 1 here

RMSEA, on the other hand, exceeded the 0.08 criteria. The model identified probable improved regression relationships, and the model was further modified to enhance the indices while maintaining theoretical logic in order to accomplish the study's objectives (Table 3).

Insert Table 3 here

A final model was produced with five latent variables (Figure 2) that were sufficient to explain the variance by replacing and deleting some of the measures to achieve the best fit model. The path coefficients and goodness of fit indices showed that the measurement model needed to be improved upon after being analysed. When modifying models in SEM, three key factors are taken into account. Finding and deleting pathways with extremely low factor loadings, removing variables identified as multi-colinear by the modification indices, and removing observed variables with extremely high values in the standardised residual correlation matrix, are a few examples of this. Additionally, model modification/refinement should result in the choice of a fitting model that not only satisfies the goodness of fit measures but also fits and meets the theoretical expectation (Molwus et al., 2017).

Insert Figure 2 here

The final model (Table 4) had a TLI =0.931, CFI=0.951, and RMSEA= 0.055. At the current state, and to maintain the theoretical objectives of the study, it can be concluded that the model fit of the confirmatory factor analysis for the modified model of the critical success factors for PPP in smart city infrastructure projects is acceptable, as it successfully meets the cut-off values.

Insert Table 4 here

Five observed variables were removed from the hypothesised measurement model after going through the steps of refinement and modification because they showed signs of multi-collinearity and had numerous high standardised residual correlations above 0.4 (Molwus et al., 2017): one from Partnership & collaboration (SF3); one from financial sustainability (SF10); and one from procurement of innovation (SF13); and the whole supportive environment latent variable. Furthermore, all of the correlations between the latent variables and two of the observable variables (SF4, SF5) have been transferred to a new construct, and SF14 to smart integration cluster (Table 5).

Insert Table 5 here

4. Results and discussion

The first cluster in the modified model, the partnership and collaboration cluster, consisted of sharing of risk and authority, commitment of parties, and coordination with other departments, political stability, social support and citizen participation. This cluster is dominated by the significance of each factor's power and interrelationships with other factors within the cluster.

Smart City initiatives offer tremendous potential for local governments to modernize their processes, increase efficiency, and cut costs, but they also present a number of security issues. Planning for Smart Cities will be made more resilient in the long run by adopting comprehensive risk management concepts (Gordon & McAleese, 2017). Given the higher replacement and repair costs associated with new technology, economic issues may arise. Smart cities may be an excessive expense for a uncertain reward or without knowledge of a future return on investment (Gordon & McAleese, 2017). These risks may increase the likelihood of PPP project failure or renegotiation. Furthermore, the use of technology will necessitate a substantial renegotiation of current contracts and may necessitate a full rethink of the economic and financial project plan (Liu et al., 2020). Risk allocation involves deciding which partner will bear the financial implications of variation in project outcomes as a result of each risk factor. The basic concept of risk allocation is that each risk should be assigned to the party most suited to managing it (Li, et al. 2005). This includes assigning risk to the party that can manage its occurrence, impact on the project, and absorb its repercussions with the least financial impact (Almarri, 2019). Furthermore, the collaboration with the private sector is contingent on government bodies' demonstration of their commitment to the project by ensuring a smooth procurement process and an efficient management process of the project's development stage; this can be accomplished by ensuring a transparent and competitive procurement process, facilitating contract negotiations and renegotiations, dealing positively with variations and eventualities, and ensuring that the project is completed on time. This is in agreement with the findings of Jayasena et al. (2020) and Gordon & McAleese (2017). The private party, on the other hand, must value all of the facilities given by the public party in order to finish the project effectively and to ensure the project's value. This involves introducing new ideas to the public for enhanced services and facilities, lowering project costs, and completing projects on time to please end users (Almarri & Boussabaine, 2017). These interaction elements and the exchange of benefits are supported by the Agency theory, which is focused on addressing two issues that may arise in the interactions. The first is the agency issue, which occurs when the objectives or aims of the principal and agent clash. The second issue is risk sharing, which occurs when the principal and agent have differing risk preferences (Eisenhardt, 1989).

Partnership, sometimes known as an alliance, has often been mentioned as a key component of project outsourcing. Partnership can minimize the risk of insufficient contractual provisions, which may be reassuring for stakeholders considering outsourcing as a complicated and high-cost function (Lambe, Spekman & Hunt, 2002). A smart city infrastructure project comprising several governmental agencies and cross-disciplines, such as the provision of integrated public information or services needing many interfaces, may be beyond the private sector's ability to manage efficiently (Lam and Yang, 2020). Strategic partnerships are formed via a balance between public authorities and private parties, with public obligations and private interests matched (Ferraris et al., 2018). Municipalities may better create and implement a smart city strategy tailored to their community's requirements by creating strategic partnerships. PPPs aid a municipality in successfully implementing its smart city strategy **(**Siokas et al., 2022). It is critical for long-term partnerships to have strong commitment from both parties (Liu et al., 2020). Negotiating skills and appropriate negotiation personnel are also part of a well-organized and devoted public agency. Because of the commercial partner's stronger position, more competent government engagement is frequently required (Muhammad & Johar, 2019). This is supported by the relational exchange theory. The key to determining how effectively contract governance is carried out, according to this theory, is in the relational rules between the transactors (Joshi & Stump, 1999).

Furthermore, successful partnership and collaboration for PPP implementation demands a stable political and social climate, which is dependent on the host government's stability and capacity (Aizwa, 2018). Political stability is essential for smart city infrastructure projects. These projects are not immune from political influence and corruption in the context of emerging economies, particularly when top-down decision-making procedures are taken into account (Yigitcanlar, 2015).

Another important factor for partnership and collaboration in smart city PPPs is social support and citizen participation. Most of the literature on public participation believes that citizen engagement, by definition, contributes to reflective debate, discursive democracy, effective representation, and consensus formation in the public sphere, as supported by the collaborative advantage theory (Gottschalk & Solli-Sæther, 2005). Arbitrary implementation of solutions and a lack of alternatives may have effects that run counter to the tenets of the smart city concept; instead of enhancing quality of life and citizen satisfaction, they may harm social ties, deepen disparities and social exclusion, lack social support, endanger privacy, and undermine social trust (Jonek-Kowalska, 2018). As a result, while engaging in a PPP scheme for smart city infrastructure projects, the government should guarantee that the private developer is accountable for satisfying the community's requirements and expectations (Muhammad and Johar, 2018)

The financial sustainability cluster that resulted from the modified model consisted of two interrelated critical success factors for smart city infrastructure projects, which are finance and asset availability, and economic sustainability. They both enhance the value of each other and contribute to the financial sustainability of the PPP project in smart cities. A systematic approach to financial sustainability analysis entails, among other things, identifying possible risks from the economic and social settings and tailoring fiscal, budgetary, and debt policies to that government's circumstances. Because it integrates financial condition into its social, economic, and political settings, this sort of financial sustainability evaluation is also known as the systemic perspective of the financial situation of governments (Puron-Cid, & Gil-Garcia, 2022).

The long-term cost of smart city initiatives is anticipated to increase as they get more technologically complicated and their context becomes more complex (Puron-Cid, & Gil-Garcia, 2022). Cities may overcome challenges in financing and administering smart city initiatives by demonstrating the potential of new technology to decrease costs and bring key essential stakeholders together (Liu et al., 2020). In this study, it was demonstrated that when the government adopts economic policies that integrate all sectors in order to generate economic growth and establishes a systematic identification of development opportunities, the private sector will feel more confident in participating in such initiatives, ensuring the financial sustainability of the smart city infrastructure project.

This research highlighted an interrelation of two critical success factors in improving the contractual obligations and outsourcing cluster in the modified model. These factors are legal framework and regulations, and shared power and resources between public and private parties.

As per the contractual theory, an outsourcing contract establishes a legally binding, institutional framework in which each party's rights, obligations, and responsibilities are documented, as well as the goals, policies, and strategies behind the relationship (Gottschalk & Solli-Sæther, 2005). An appropriate and flexible dispute resolution mechanism should be provided to assist in guaranteeing the adherence to contractual obligations and the stability of the PPP arrangements. PPPs in smart city infrastructure projects should be viewed as flexible agreements between public bodies and private players based on the introduction of technological innovations, rather than as a specific and inflexible type of PPP. This view of the flexibility of PPPs in smart city infrastructure projects is supported by Selim et al. (2018).

In order for the project to be completed successfully, both sides must demonstrate leadership. There must be a mutual awareness of the necessity of both parties' engagement in operating the PPP project in order to maximize the possibility of meeting output requirements and minimize risks and their associated circumstances on the project. The public party should not take any actions that impact the project's operation without first consulting with the private party, nor should the private party make decisions that impact the project's pre-determined objectives without first consulting with the public party. To avoid disputes, the scope of each party's assurance of shared leadership of the project should be explicitly specified and agreed upon before the signing of the agreement, as supported by Hoeft et al. (2021) . Furthermore, according to Hoeft et al. (2021), for PPP in smart city infrastructure projects, platformization can be a cost-effective way to share resources. It also opens up new opportunities for more adaptable project frameworks, in which a diverse set of players may contribute to innovative infrastructure operations in a modular fashion. This is also in line with the Resource-based View (RBV) theory, which advocates the investigation of how resources may be leveraged to gain a competitive advantage. Based on this theory, outsourcing should be viewed as a strategic choice that may be utilized to address gaps in the firm's resources and skills to be deployed in PPPs of smart city infrastructure projects (Almarri & Gardener, 2014).

The fourth cluster of the model was the smart integration cluster, which consisted of three interrelated critical success factors; technological innovation and rate of diffusion, availability of expertise and data, and integration with other smart city initiatives. The complimentary interrelation of these factors improves the integration of smart city infrastructure projects.

Public-private partnerships in smart cities are becoming prevalent as governments pool their resources with those of private parties to enhance service delivery and citizen quality of life (Liu et al., 2020). To achieve a quicker diffusion of these innovative services, private players must be allowed more flexibility in their methods for creating and marketing new products. This is in line with the innovation diffusion theory, which focuses on how, why, and at what pace innovative ideas and technology spread in a social system (Wani & Ali, 2015).

To ensure the effective deployment of PPPs in smart cities and infrastructures, management processes and procedures must be innovative (Selim et al., 2018). Furthermore, a smart city is built using large amounts of data gathered from citizen behaviour. This data is critical for a smart city since it may be utilized to give information on asset performance and optimization (Liu et al., 2020).

A city can more effectively use its resources, plan its preventive maintenance activities, and monitor security aspects while maximising services to its citizens if it monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, and even major buildings (Hall, 2000). With all the technical advancement, the notion of the smart city must be accessible to all facets of social, economic, and emotional life. They draw the main natural, organisational, technical, and human resources. Therefore, integrated smart cities should be constructed, where knowledge of integration will be applied in all spheres of life. This will raise the standard of living, promote economic expansion, maintain the budget of the local government, and provide new value for both investors and the local community (Hodžić & Arnautović, 2019).

And finally, the contract governance cluster consisted of two interrelated factors: a competitive procurement process, and clear project brief and performance measurements. The study's findings established the complementary impacts of satisfying these factors concurrently. Ensuring the achievement of these factors enhances the governance of PPP contracts in smart city infrastructure projects. Smart cities must be capable of identifying and procuring the best solution for their citizens and companies. The procurement process should be leveraged to boost sustainable innovation. PPPs should be encouraged, as should greater collaboration with business. For that matter, setting explicit evaluation criteria for evaluating the technical or qualitative aspects of bids is critical (Milenković et al.,2022).

Developing standardised performance measures for smart cities that offer meaningful, city- and citizen-centered evaluation is a major issue. Currently, standards and metrics for smart cities are being developed as a result of national and international standardisation projects, which are also influencing urban development strategies. Additionally, standardised performance measurements have the capacity to change governance and are valuable for development policy (Caird & Hallett, 2019).

5. Conclusions

PPPs are critical for addressing the financial challenges that arise with infrastructure projects, as well as ensuring that these projects meet their economic and social objectives. Despite the fact that PPP critical success factors offer evidence of their advantages in boosting PPP project success rates, previous research did not investigate the critical success factors in smart city infrastructure projects. The aim of this study was to establish the PPP critical success factors in smart city infrastructure projects, categorizing them into clusters and establishing their interrelationships, as well as how this impacts the success of PPPs in smart cities and infrastructure projects. The developed model depicted the causal relationships among the important success factors for the PPP, which may aid in improving the public client's ability to meet and fulfil the needs for smart city initiatives.

This study used a three-tiered method to identify the CSF for smart city infrastructure projects: a comprehensive literature review, data collection using a Likert scale questionnaire, and identification of the most significant factors and estimating interrelationships among them using structural equation modelling.

None of the current PPP CSF studies has considered the categorization of critical success factors as a primary goal, particularly for the sort of smart city infrastructure projects under consideration.

This research contributes to the theoretical understanding of the significance of the PPP critical success factors by expanding their contribution in a novel way through the establishment of the underpinned clusters and interrelationships and extending their utilization to the smart city sector. The study produced modified factors and discovered that some CSF have grown in importance since they not only contribute to higher success, but also have a substantial impact on other factors.

This research has produced a usable and readily applicable list and clusters of critical success factors for the implementation of PPP in smart city infrastructure projects, which aids public sector management by providing a measure of pre-conditions that can be utilized as an assessment tool. It therefore aids in overcoming the problems associated with resource allocation and achieving the minimal requirements before committing to the PPP approach. When developing a PPP for smart city infrastructure projects, public sector managers should think about how a group of critical success factors may be more important when looked at together.

This study introduced the critical success factors for public-private partnerships and their interdependence to improve the outcomes for smart city infrastructure projects, which have never been previously covered. This study adds to the body of knowledge on public-sector PPP by providing new research avenues that may be followed in future studies. It offers a clear approach derived directly from the requirement to create new CSF criteria that are highly adaptable for smart city infrastructure projects. The updated 18 critical success factors found in this study can be used in any study that looks at PPP in smart city infrastructure projects.

It may be necessary to use two separate CSFs for PPP models, one for developing countries and the other for developed ones. The created model's contribution is to offer a fundamental framework for launching a thorough knowledge of the possible success factors for accelerating the development of smart city infrastructure through PPP. This model might be improved and extended further using data that is based on each country's unique features. PPPs vary by country, depending on their economic climate and political landscape. As a result, more research is needed to figure out which PPP critical success factors are best for smart city infrastructure projects based on the country's current goals, limitations, and conditions.

The study's limitations were mainly related to the sample size and a focus on the UAE and the UK. Additional studies to determine the CSFs for developed and developing countries separately would be necessary for the study to be validated. A comparable analysis ought to come next. This was not achievable because of the small sample that was taken in the UAE. Future research should attempt to use random sampling, bigger sample sizes, and more people from different backgrounds.

References

Abdul-Aziz, A. R., & Kassim, P. J. (2011). Objectives, success and failure factors of housing public–private partnerships in Malaysia. *Habitat International*, *35*(1), 150-157.

Alavi, M., Visentin, D. C., Thapa, D. K., Hunt, G. E., Watson, R., & Cleary, M. L. (2020). Chi-square for model fit in confirmatory factor analysis. J Adv Nurs, 76 (2020), pp. 2209-2211

Alfen, H. (2010). Public Private Partnership (PPP) as part of Infrastructure Management solutions – a structural approach of delimiting PPP from other Private Sector participation Models. *18th CIB World Building Congress*, May 2010 Salford, United Kingdom.

Allen, M., Alleyne, D., Farmer, C., McRae, A., & Turner, C. (2014). A framework for project success. *Journal of Information Technology and Economic Development*, *5*(2), 1.

Almarri, K. (2019). Perceptions of the attractive factors for adopting public–private partnerships in the UAE. *International Journal of Construction Management*, *19*(1), 57-64.

Almarri, K., & Boussabaine, H. (2017). Interdependency of the critical success factors and ex-post performance indicators of PPP projects. *Built Environment Project and Asset Management*.

Babatunde, S. O., Opawole, A., & Akinsiku, O. E. (2012). Critical success factors in public-private partnership (PPP) on infrastructure delivery in Nigeria. *Journal of facilities management*.

Bentler, P. (2007). On tests and indices for evaluating structural models. *Personality and Individual Differences*, 42 (5), pp. 825-829.

Bryman, A. (2008). *Social Research Methods* (3ed. Ed.). Oxford: Oxford University Press.

Caird, S. P., & Hallett, S. H. (2019). Towards evaluation design for smart city development. Journal of urban Design, 24(2), 188-209.

Chan, A. P., Lam, P. T., Chan, D. W., Cheung, E., & Ke, Y. (2010). Critical success factors for PPPs in infrastructure developments: Chinese perspective. *Journal of construction engineering and management*, *136*(5), 484-494.

Cruz, C. O., & Sarmento, J. M. (2017). Reforming traditional PPP models to cope with the challenges of smart cities. *Competition and Regulation in Network Industries*, *18*(1-2), 94-114.

Eisenhardt, K. M. (1989). Agency theory: An assessment and review. *Academy of management review*, *14*(1), 57-74.

EU- European Commission. (2003). Guidelines for successful public – private partnerships., Directorate-General Regional Policy, Directorate General for Research. Brussels.

Ferraris, A., Santoro, G., & Papa, A. (2018). The cities of the future: Hybrid alliances for open innovation projects. *Futures*, *103*, 51-60.

Fishman, T. D., & Flynn, M. (2018). Using Public-Private Partnerships to Advance Smart Cities. *Deloitte Center for Government Insights: London, UK*.

Gordon, L. W., & McAleese, G. W. (2017). Resilience and Risk Management in Smart Cities. The CIP Report.

Gottschalk, P., & Solli-Sæther, H. (2005). Critical success factors from IT outsourcing theories: an empirical study. Industrial Management & Data Systems.

Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., & Williams, P. (2010). Foundations for smarter cities. *IBM Journal of research and development*, *54*(4), 1-16.

Hatcher, L., & O'Rourke, N. (2013). *A step-by-step approach to using SAS for factor analysis and structural equation modeling*. Sas Institute.

Henjewele, C., Sun, M., & and Fewings, P. (2011). Critical parameters influencing value for money variations in PFI projects in the healthcare and transport sectors. Construction Management and Economics, 29(8), 825-839.

Hodžić, S., & Arnautović, S. (2019). The Financing Incentives for Smart Cities and Importance for Local Government. Public Administration Reform: European Union Issues and Challenges, 1-9.

Hoeft, M., Pieper, M., Eriksson, K., & Bargstädt, H. J. (2021). Toward Life Cycle Sustainability in Infrastructure: The Role of Automation and Robotics in PPP Projects. *Sustainability*, *13*(7), 3779.

Huxham, Chris, and Siv Vangen. 2005. Managing to collaborate: The theory and practice of collaborative advantage. New York, NY: Routledge.

Ismail, S., (2013). Drivers of value for money public private partnership projects in Malaysia". *Asian Review of Accounting, Vol. 21* Iss (3), pp. 241–256.

Jayasena, N. S., Chan, D. W., & Kumaraswamy, M. (2020). A systematic literature review and analysis towards developing PPP models for delivering smart infrastructure. *Built Environment Project and Asset Management*.

Jefferies, M., Gameson, R., & Rowlinson, S. (2002). Critical success factors of the BOOT procurement system: reflections Reflections from the Stadium Australia case study. *Engineering Construction and Architectural Management*, *9*(4), 352-–361.

Jonek-Kowalska, I., Kaźmierczak, J., Kramarz, M., Hilarowicz, A., & Wolny, M. (2018). Introduction to the research project “Smart City: a holistic approach”. In SGEM2018 Conference Proceedings (Vol. 5, No. 2, pp. 101-112).

Joshi, A. W., & Stump, R. L. (1999). Determinants of commitment and opportunism: Integrating and extending insights from transaction cost analysis and relational exchange theory. *Canadian Journal of Administrative Sciences/Revue Canadienne des sciences de l'administration*, *16*(4), 334-352.

Kabue, L. W., & Kilika, J. M. (2016). Firm resources, core competencies and sustainable competitive advantage: An integrative theoretical framework. *Journal of management and strategy*, *7*(1), 98-108.

Lam, P. T., & Yang, W. (2020). Factors influencing the consideration of Public-Private Partnerships (PPP) for smart city projects: Evidence from Hong Kong. *Cities*, *99*, 102606.

Lambe, C. J., Spekman, R. E., & Hunt, S. D. (2002). Alliance competence, resources, and alliance success: conceptualization, measurement, and initial test. *Journal of the academy of Marketing Science*, *30*(2), 141-158.

Li, B., Akintoye, A., Edwards, P. J., & Hardcastle, C. (2005). The allocation of risk in PPP/PFI construction projects in the UK. *International Journal of Project Management*, *23*(1), 25-–35.

Liu, J., Love, P. E., Smith, J., Regan, M., & Davis, P. R. (2015). Life cycle critical success factors for public-private partnership infrastructure projects. *Journal of Management in Engineering*, *31*(5), 04014073.

Liu, J., Love, P. E., Smith, J., Regan, M., & Sutrisna, M. (2014). Public-Private Partnerships: a review of theory and practice of performance measurement.*International Journal of Productivity and Performance Management*, *63*(4), 499-512.

Liu, T., Mostafa, S., Mohamed, S., & Nguyen, T. S. (2020). Emerging themes of public-private partnership application in developing smart city projects: a conceptual framework. *Built Environment Project and Asset Management*.

Malek, M., & Gundaliya, P. (2021). Value for money factors in Indian public-private partnership road projects: An exploratory approach. *Journal of Project Management*, *6*(1), 23-32.

Manhas, P. S., Manrai, A. K., Manrai, L. A., & Ramjit. (2013). Role of Structural Equation Modelling In Theory Testing And Development. In Quantitative Modelling In Marketing And Management (pp. 27-42).

McQuitty, S. (2004). Statistical power and structural equation models in business research. *Journal of Business Research*, 57 (2), pp. 175-183.

Medeiros Jr, A. D., Perez, G., & Lex, S. (2014). Using analytic network for selection of enterprise resource planning systems (erp) aligned to business strategy. *JISTEM-Journal of Information Systems and Technology Management*, *11*(2), 277-296.

Meyer, K. S. (2012). Testing Tradition: Assessing the Added Value of Public-Private Partnerships. *The National Council for Public-Private Partnerships, Arlington, VA.*

Milenković, M., Rašić, M., & Jovančević, R. (2022). Public Procurement of Innovative and Technological Solutions in the EU. In 2022 45th Jubilee International Convention on Information, Communication and Electronic Technology (MIPRO) (pp. 1258-1263). IEEE.

MIT CISR. (20167). Remembers Jack Rockart. Retrieved from http://cisr.mit.edu/blog/blogs/2014/02/05/jack-rockart/

Moss, S. (2016). Fit indices for structural equation modeling. [online] Available at: https://www.sicotests.com/psyarticle.asp?id=277 [Accessed 2 November 2021].

Muhammad, Z., & Johar, F. (2019). Critical success factors of public–private partnership projects: a comparative analysis of the housing sector between Malaysia and Nigeria. *International Journal of Construction Management*, *19*(3), 257-269.

Osei-Kyei, R., & Chan, A. (2015). Review of studies on the Critical Success Factors for Public–Private Partnership (PPP) projects from 1990 to 2013. *International Journal of Project Management*, 33(6), 1335-1346.

Puron-Cid, G., & Gil-Garcia, J. R. (2022). Are Smart Cities Too Expensive in the Long Term? Analyzing the Effects of ICT Infrastructure on Municipal Financial Sustainability. Sustainability, 14(10), 6055.

Schreiber, J. B. (2008). Core reporting practices in structural equation modeling. *Research in social and administrative pharmacy*, *4*(2), 83-97.

Selim, A. M., Yousef, P. H., & Hagag, M. R. (2018). Smart infrastructure by (PPPs) within the concept of smart cities to achieve sustainable development. *International Journal of Critical Infrastructures*, *14*(2), 182-198.

Siokas, G., Kelaidi, V., & Tsakanikas, A. (2022). The smart city as a hub for nourishing public-private partnerships. Sustainable Cities and Society, 76, 103466.

Soomro, M. A., & Zhang, X. (2016). Evaluation of the functions of public sector partners in transportation public-private partnerships failures. *Journal of Management in Engineering*, *32*(1), 04015027.

Tan Yigitcanlar (2015) Smart cities: an effective urban development and management model?, Australian Planner, 52:1, 27-34, DOI: 10.1080/07293682.2015.1019752

The University of Texas at Austin (UoT) (2012). Structural Equation Modeling Using AMOS, An Introduction. Division of Statistics &Scientific Computation.

The World Bank Institute. (WBI), (2012), *Public-Private Partnerships, Reference Guide Version 1.0.*

Tran Thi Hoang, G., Dupont, L., & Camargo, M. (2019). Application of Decision-Making Methods in Smart City Projects: A Systematic Literature Review. *Smart Cities, 2(3), 433-452.*

Tucker, L. R., & Lewis, C. (1973). A reliability coefficient for maximum likelihood factor analysis. *Psychometrika*, *38*(1), 1-10.

Ullah, A. (2016). Prospects of Smart Cities Development in India Through Public Private Partnership. *International Journal of Research in Advent Technology*, *4*(1).

Ullman, J. B. (2001). Structural equation modeling in Using Multivariate Statistics, 4th Edn, eds Tabachnick BG, Fidell LS.

United Nations Conference on Trade and Development (UNCTAD) (2016) PPP for Cities, Inter-Sessional Panel on Smart Cities and Infrastructure and Foresight for Digital Development, Washington, DC

Vadgama, C. V., Khutwad, A., Damle, M., & Patil, S. (2015). Smart funding options for developing smart cities: A proposal for India. *Indian Journal of Science and Technology*, *8*(34), 1-12.

Wani, T. A., & Ali, S. W. (2015). Innovation diffusion theory. *Journal of general management research*, *3*(2), 101-118.

Yuan, J., Zeng, A. Y., Skibniewski, M. J., & Li, Q. (2009). Selection of performance objectives and key performance indicators in public–private partnership projects to achieve value for money. *Construction Management and Economics*, *27*(3), 253-–270.

Table 1: Identification of the critical success factors (Source: Authors own creation)

CSF code	Item	Li et al. (2005)	Chan et al. (2010)	Ismail (2013)	Babatunde et al. (2012)	Dulaimi et al. (2010)	Liu and Wilkinson	Abdul-Aziz and Kassim	Zayyanu & Johar (2018)	Cheung et al. (2012)	Malek & Gundaliva (2020)	
SF1	Sharing of risk and authority	X			X				X	X	X	X
SF2	Commitment of parties and coordination with other departments	X		X					X	X	X	
SF3	Competence of public agency	X							X	X		
SF4	Competitive procurement process	X	X		X		X	X	X	X	X	X
SF5	Clear project brief and performance measurements	X			X	X		X			X	X
SF6	Legal framework and regulations	X		X	X	X			X	X	X	
SF7	Shared authority and resources between public and private parties					X	X					
SF8	Government guarantees	X			X		X		X	X		
SF9	Finance and asset availability	X		X					X	X	X	X
SF10	Macro-economic conditions	X	X	X	X	X	X		X	X		
SF11	Multi-benefit objectives of all stakeholders	X							X	X	X	
SF12	Political stability	X	X		X	X		X	X	X		
SF13	Transparent procurement process	X							X	X		X
SF14	Technological innovation and rate of diffusion		X					X	X	X		X
SF15	Social support and citizen participation	X	X			X			X	X		
SF16	Economic sustainability	X	X	X	X		X		X			
SF17	Availability of expertise and data					X	X		X	X		X
SF18	Integration with other smart city initiatives								X		X	

Table 2. Constructs and measures of conceptual measurement model of CSFs for smart city projects. **(**Source: Authors own creation**)**

Constructs	***Measures***
Partnership & collaboration	SF1- Sharing of risk and authority SF2- Commitment of parties and coordination with other departments SF3- Competence of public agency SF4- Competitive procurement process SF12- Political stability SF15- Social support and citizen participation
Financial sustainability	SF5- Clear project brief and performance measurements SF10- Macro-economic conditions SF9- Finance and asset availability SF16- Economic sustainability
Contractual obligations and outsourcing	SF6- Legal framework and regulations SF7- Shared authority and resources between public and private parties
Smart integration	SF17- Availability of expertise and data SF18- Integration with other smart city initiatives
Procurement of innovation	SF13-Transparent procurement process SF14-Technological innovation and rate of diffusion
Supportive environment	SF8- Government guarantees SF11- Multi-benefit objectives of all stakeholders

Table 3. Standardized regression weights of the best fitting measurement model for the CSF in SM. **(**Source: Authors own creation**)**

Direct path	***Estimate***	***S.E.***	***C.R.***	***P***
SF2<--------1	1.000			
SF15<------1	0.962	.252	3.811	***
SF1<--------1	.941	.192	4.899	***
SF12<------1	1.218	.252	4.827	***
SF9<--------2	1.000			
SF16<------2	1.153	.208	5.541	***
SF7<--------3	1.000			
SF6<--------3	1.467	.270	5.428	***
SF14<------4	1.000			
SF17<------4	1.089	.252	4.322	***
SF18<------4	1.243	.275	4.525	***
SF5<--------5	1.000			
SF4<--------5	.797	.219	3.644	***

Table 4. Final model indices and adjusted measures. **(**Source: Authors own creation**)**

Model	***NFI***	***RFI***	***IFI***	***TLI***	***CFI***	***RMSEA***
Default model	.820	.745	.955	.931	.951	0.055
Saturated model	1.000		1.000		1.000	
Independence model	.000	.000	.000	.000	.000	0.210

Table 5 The best fit measurement model of CSFs for PPPs in smart city projects. **(**Source: Authors own creation**)**

Constructs	***Measures***
Partnership & collaboration	SF1-Sharing of risk and authority SF2-Commitment of parties and coordination with other departments SF12-Political stability SF15-Social support and citizen participation
Financial sustainability	SF9-Finance and asset availability SF16-Economic sustainability
Contractual obligations and outsourcing	SF6-Legal framework and regulations SF7-Shared authority and resources between public and private parties
Smart integration	SF14-Technological innovation and rate of diffusion SF17-Availability of expertise and data SF18-Integration with other smart city initiatives
Contract governance	SF4-Competitive procurement process SF5-Clear project brief and performance measurements

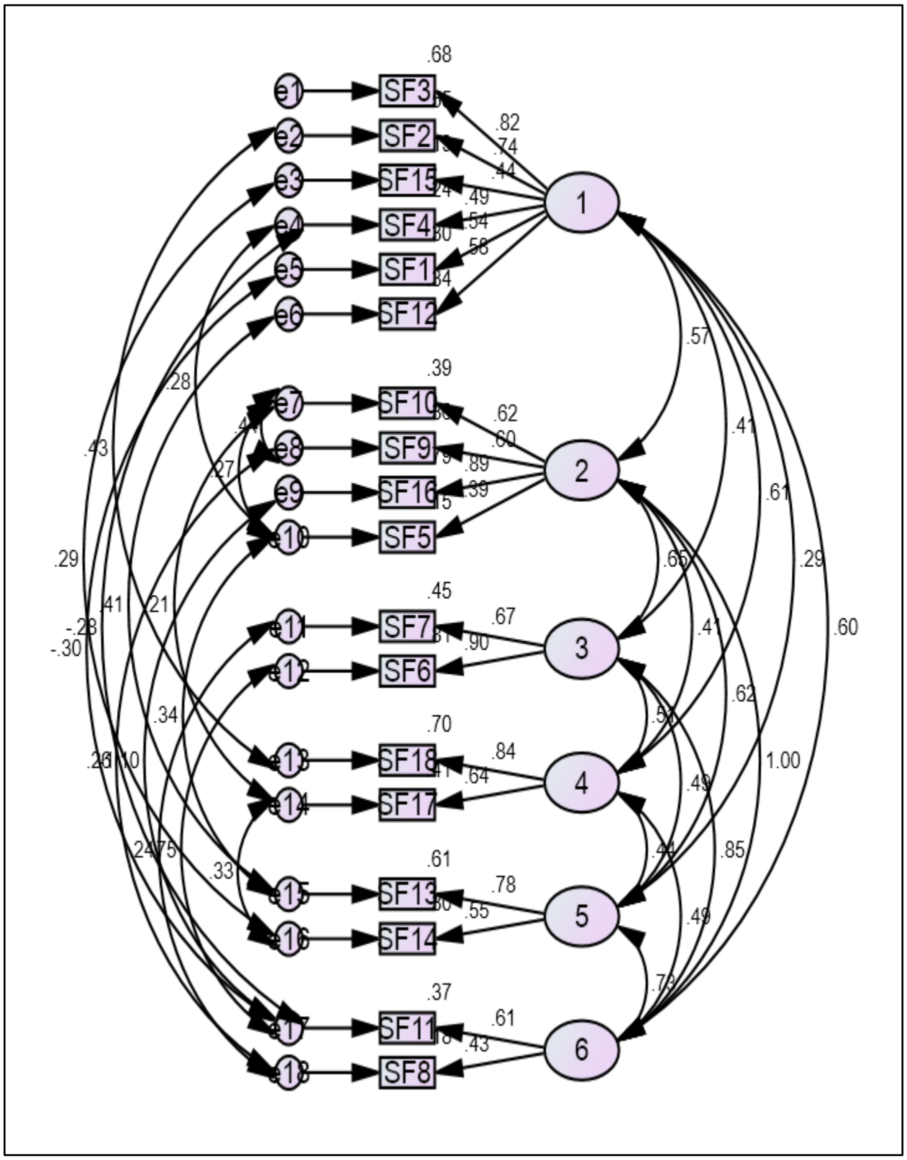

Figure 1. CFA for PPP critical success factors. **(**Source: Authors own creation**)**

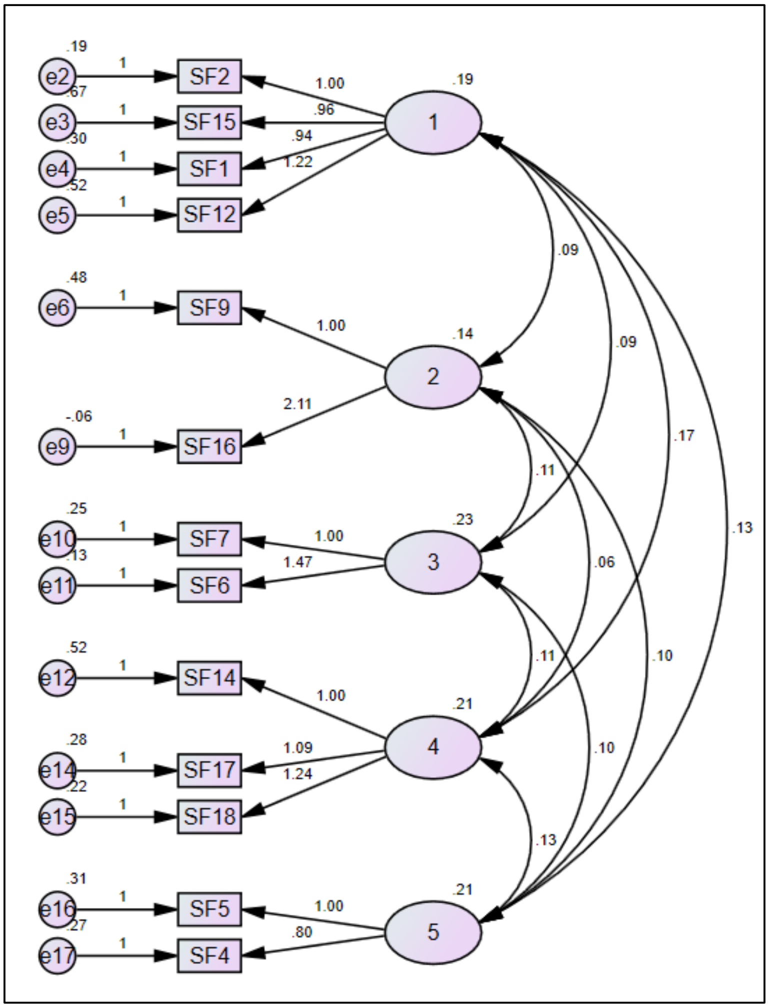

Figure 2. Improved CFA for PPP critical success factors. **(**Source: Authors own creation**)**