A Systematic Literature Review and Analysis towards Developing PPP Models for Delivering Smart Infrastructure

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Abstract

Purpose

Rising human aspirations leading to rapid urbanization, amidst climate changes, and other environmental pressures, have aggravated the needs for better-focused sustainable urban development in general, as well as for smart and sustainable cities in particular. Indeed, Smart Infrastructure (SI) development is a prerequisite for Smart Cities (SCs). However, inadequate funding and expertise for such SI development pose profound challenges that may be partially addressed by mobilising private finance and efficiencies through collaborative Public-Private Partnership (PPP) models. This paper provides a holistic review and analysis of the relevant literature, as a basis for proposing such PPP models for developing SI.

Design/methodology/approach

A systematic literature review helped to fulfil the aim of this paper in the first phase of the underlying longer-term study. Authoritative search engines like Scopus and Web of Science Indexed articles were reviewed and analysed, 85% of these being journal articles.

Findings

SCs that necessarily include SI are important in overcoming current urban challenges in developing and developed countries. Given shortfalls in traditional procurement and funding models, special PPP models are required for SI development. After identifying the relevant needs, drivers, barriers and challenges in different countries, a general indicative framework is developed to illustrate how the various interacting force-fields can be harnessed to develop the envisaged PPP models that can complement non-PPP procurement models.

Originality/value

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PPP for SI development is a relatively new, hence under-researched topic. This systematic literature review and analysis provide a useful guide for the development of SI through overcoming the potential challenges in traditional procurement and financial models.

Key words: Public-Private Partnership, Smart Cities, Smart Infrastructure

1. Introduction

The Economic and Social Council (ECOSOC) of the United Nations, being the central platform for reflection, debate, and innovative thinking on sustainable development, stated that over 60 percent of the global population will reside in cities by 2030 (ECOSOC, 2016). Such rapid urbanisation generates profound challenges, for example, arising from uncontrolled developments, traffic congestions, crimes, waste management problems, and limited access to resources (Peris-Ortiz et al., 2017). According to Milenković et al. (2017), cities around the world are highly impacted by emerging trends in rapid urbanization, new technological developments, increased connectivity, demographic shifts, climatic issues and scarcity of natural resources. As confirmed by Cruz and Sarmento (2017), cities in both developed and developing countries are under pressure. These demands pose significant challenges in managing cities. As described by Schaffers et al. (2011), the 'SC' concept is a response to guide pathways of urban development in strategic directions to address such challenges and achieve sustainability.

Development of SCs pays attention to the general needs of the citizens and also satisfies their different needs (Lin et al., 2019). Milenković et al. (2017) identified that the development of SCs have motivated many governments to develop a more liveable environment that also brings several benefits for the citizens. The discussion on the development of SCs cannot be separated from the discussion on SI (Cruz and Sarmento, 2017). According to Anthopoulos et al. (2019), SI and smart services are the core elements of a SC. Therefore, the development of SI could be determined as a critical component in SC development. Though there is a growing requirement for developing SI, challenges arise in funding the projects (Yigitcanlar and Lee, 2014). As mentioned by Spicer et al. (2019), SC technology is expensive and, smaller municipalities usually face unique fiscal constraints in SI development. Moreover, De Marco et al. (2013) also found that, the development and implementation of SC projects require considerable

investments that are difficult to fund with traditional public finance. These challenges, along with the need for special efficiencies that are usually associated with the private sector rather than a bureaucratic public sector, highlight the importance of Public-Private Partnership (PPP) for SI development. The aim of this research paper is to enhance SI development. Hence, the research objectives are to investigate the importance of SCs, the importance of SI in the development of SCs and also the potential significance of PPP in SI development via a systematic literature review and analysis. The structured analysis and consolidation of the review findings lead to a logical formulation of a general indicative framework that visualises potential pathways towards developing the envisaged PPP models that would complement non-PPP procurement models, so as to boost SI development.

2. Research Approach and Methods

A systematic literature review approach was adopted in the study to conduct a clear and comprehensive overview of available research and findings on this topic. "Systematic literature review enables researchers to collect, analyze, and integrate academic contributions on a certain research topic in a reproducible and transparent manner" (von Danwitz, 2018, p.526). Systematic literature reviews guide searches in the identification of central themes, approaches, and results of a given field of research; and are advantageous in the investigation on the gaps and prospective research questions (von Danwitz, 2018; Yigitcanlar, et al., 2019).

Tawfik et al., (2019) defines systematic review as review undertaken using a systematic method to summarize a detailed question with a thorough and comprehensive study plan.

Several stages in systematic review process can be identified (Uman, 2011; Raouf and Al-Ghamdi, 2019; Cronin, et al., 2008, Yigitcanlar, et al., 2019). These are summarised in Figure 1 in the context of the scope of the current research exercise and incorporating the parameters chosen in this scenario.

Figure 1: Stages, research tasks and basic outputs of the systematic literature review process

First, it is important to formulate the review question, to capture the aim and scope of the study and accordingly decide the keywords for conducting the systematic literature review. Researches such as Tawfik et al., (2019), Verweij and Trell (2019) and Robinson and Lowe (2015) confirmed that defining the review question to be addressed is the first step in carrying out systematic literature review. In this research, two essential review questions were

formulated as follows and the systematic review strives to answer the following review questions in order to meet the aim of the study.

(i) What is the importance of SCs and what are the key benefits of SI for the development of SCs that have been identified in the literature?
(ii) What is the potential significance of PPP in the development of SI and what are the drivers and barriers in adopting PPP in SI development?

The second stage involved searching for relevant research articles. 'Smart City', 'Smart Infrastructure' and 'Public Private Partnership' were selected as the search keywords after the development of the review questions. Research articles were sought using the search keywords all together in the common search engines, i.e. Scopus and Web of Science. Parahoo (2006) indicated that a systematic review should detail the time frame within which the literature was selected. The concepts, initiatives, importance and development of SCs emerged increasingly over the last 15 years. This is confirmed by the significant increase of the publications in the research area in the last 15 years compared to previous years. In the search of 'SI', 'SC' with 'PPP', publications listed in Scopus and WoS significantly increase from 2005 onwards. To capture this surge, this research was primarily limited to review research publications in 2005-2019. In the search of all the key words together in 2005-2019, nearly 1373 publications were identified. This total number was obtained by filtering the findings through the language (English) and publication status (published). The identified articles were analysed in terms of articles in each year, as presented in Figure 2.

Figure 2: Number of published articles on 'SC', 'SI' and 'PPP' per year

Figure 2 shows that the number of articles on 'SC', 'SI' and 'PPP' published in each year have drastically increased. This significant increase of the total number of articles per year denotes the upsurged requirement of research into SC, SI with PPP worldwide. Therefore, PPP in SC/SI development was confirmed to be a noteworthy meaningful research area.

The sourced publications were next screened by removing the duplicates and through screening the titles of the publications. Only 113 research articles were thereby selected from the listed search results from the two databases for screening in this review study, as those papers were determined to be the most relevant publications for the study after removing some with overlaps. Abstracts of these 113 articles were screened and 74 articles were selected for the

systematic literature review in order to carry out this research study. Out of these 74 publications, 63 were indexed journal articles and 11 were conference publications.

The content review of the selected research publications, led to findings that answer the review questions, which are discussed in the next sections after which the conclusions were derived.

3. Findings of the Systematic Literature Review

3.1 The Concept of SCs

In the last two decades, the concept of SCs has become a widespread theme of discussion in scientific literature and international policies (Albino et al., 2015). Researchers from various disciplines such as political science, engineering, geography, urban studies, law, philosophy, ethics and mathematics have engaged in scientific research on planning and adopting of SCs (Spicer et al., 2019; Attour, et al., 2015). Therefore, various definitions on the concept of SCs can be found in the literature in accordance with the diverse source disciplines. Table 1 illustrates some definitions identified through the literature survey and classified the keywords according to the impact area, tools/ processes and goals/objectives

Table 1: Definitions and key words of SCs sourced from systematic literature review

Essential elements of a SC include the city, citizens, and knowledge, intelligence, innovation, smart systems, infrastructure and urban technologies (Komninos, et al., 2019). Various initiatives of SCs aim to improve urban performance with the use of data, information and Information Technologies to monitor and optimize existing infrastructure to provide a better liveable environment for the citizens (Marsal-Llacuna et al., 2015). SCs use several technologies to upgrade the performance of health, transportation, energy, education, and water services, which result in a higher level of quality of life of the citizens (Al Nuaimi et al., 2015). According to Abdel-Basset and Mohamed (2018), people, governance, policy, technology, economy, infrastructure and natural environment are the most important factors for the development of SCs. The analysis of the existing definitions of SCs in Table 1 enables identification of a wide variety of key phrases/words. Finding that ‘citizens’, ‘ICT’, and ‘infrastructure’ play a significant role in SCs, illustrates the importance of research enhancing

the development of SI for the development of SCs worldwide. Moreover, it can be determined that smart initiatives play a key role in improving the liveability and quality of life of the citizens. Nevertheless, the SC concept is clearly a broader concept that encompasses even more disciplines.

3.2 SI for the Development of SCs and Barriers to SI Development

Following on from the above, SI is clearly an essential corner-stone of SC development. Chourabi et al. (2012), Nam and Pardo (2011) and Soyinka et al. (2016) also highlighted the importance of SI in developing SCs and achieving sustainable urban development, while addressing current urban challenges. According to Hoult et al. (2009), SI is required to be developed and managed in a way that ensures safe and efficient operation, which delivers the functional requirement of the infrastructure. Therefore, it can be concluded that SI development has become a growing imperative with the accelerating importance of SCs. Rapid urbanisation, uncontrolled development, traffic congestion, crime, waste management and limited natural resources must be addressed together with SI development.

SI is defined as an interconnected network of basic facilities and services with efficient land use pattern, transportation network and coordinated information technology devices (Litman, 2017). According to Soyinka et al. (2016), "SI is a structure of basic facilities and services that are interconnected and driven by technologies" (p.55). To develop SI, specific forms of smart ICT, such as Building Information Modelling (BIM) software, Asset Management System (AMS) and Intelligent Transport Systems (ITS) could be utilised (Albino et al., 2015; Yigitcanlar, 2015). According to Cruz and Sarmento (2017), SI refers to the physical supporting urban infrastructure systems, such as roads, water systems, railways, metros, etc. As described by Anthopoulos (2017), SI includes hard infrastructure (all urban facilities) and soft infrastructure (people, business processes, software applications and data), which are equipped with the latest ICT to provide corresponding smart services. In this research paper, both hard infrastructure and soft infrastructure are included in infrastructure to be developed as SI.

As stated by ECOSOC (2016), SI provides the foundation for all of the key themes related to a SC, including smart people, smart mobility, smart economy, smart living, smart governance

and smart environment. Moreover, smart transportation systems, smart energy management systems, smart water supply, smart waste management and smart health services are identified as important types of SI for SCs. As described by Novotný et al. (2014), SIs can be implemented in general municipal and business services, education, health, social care, utility production and supply, public safety, security and transportation systems. SI are required to be developed in utility supply, communication systems and transportation systems as they are the foundation of the modern society (Ogie et al., 2017).

In SI development, some challenges were identified in the literature. Veselitskaya et al. (2019) described inconsistency between stakeholders' interests, security issues in the automated systems, lack of resources and citizen participation as the major challenges to SI development. Höjer and Wangel (2015), Rana et.al. (2019) and Bakıcı, et al. (2013) also described inadequacy of resources as a main challenge obstructing SI development. Moreover, lack of knowledge and competencies, political uncertainties and the diversity of stakeholders are other challenges (Vilajosana et al., 2013; Scuotto et al., 2016). By considering the above, inconsistency between stakeholder agendas, reliability/ security of automated systems, lack of resources, limited knowledge and competence, lack of citizen participation, political uncertainties and disorganised funding structures can be recognised as basic barriers to SI development. An overview of the challenges facing SI, could summarise 'lack of resources' as the overall major challenge. This is unsurprising, given that more advanced technology is needed for SI, compared to conventional infrastructure. Objective 1, which corresponds to the review question 1, was achieved through the findings of Section 3.1 and 3.2.

3.3 PPP Applications and Contributions to SI Development

Expanding on the 'lack of resources' constraint identified above, funding was regarded as inadequate in most of the infrastructure development projects (Leviäkangas et al., 2016). SI development requires support from municipalities and needs partnerships funded and supported by subsidies (van Winden and van den Buuse, 2017). Scuotto et al. (2016) stated that barriers in building knowledge and creating relationships with external stakeholders must be overcome, in order to successfully initiate SCs. Moreover, De Marco et al, (2013) also found that, the development and implementation of SI development projects require considerable investments that are difficult to fund with traditional public finance. Since SI cannot be managed by the governments themselves, the private sector and other stakeholders must be mobilised to work together. As discussed by Koppenjan and Enserink (2009), PPPs are driven

by rapid urbanization, shortage of public funds and inadequacies of public services in maintaining, building and operating urban infrastructure. Moreover, Nguyen et al. (2019) explained how PPP could leverage big data for commercial use after the recent innovations in SI, to develop software and hardware, for gathering and processing big data. Meanwhile, PPPs are increasingly adopted to develop built infrastructure (CICID, 2009; Akintoye et al., 2016). Therefore, more costly capital investment demands amidst lower financial resources availabilities, coupled with these emerging requirements for 'high-tech' innovative technologies, need for higher-level skills/ capacities and the underlying imperative to accelerate SI development can be concluded to be a synergistic set of drivers of PPPs for better, faster and more efficient SI development.

Chan et al. (2010) identified PPP as the ideal solution for many public SI service projects in both China and overseas. Milenković et al. (2017) advocated PPP models, as providing better outcomes in developing SI because crowdsourcing and democratic ecologies provide better and more efficient public services by mobilising private sector competencies. PPP benefits all the stakeholders in a SC deployment and is one of the popular implementation models used for SI (Vilajosana et al., 2013). PPPs are used in both developed and developing countries with the increasing involvement of the private sector in the provision public infrastructure development (Chan et al., 2009; Levin and Tadelis, 2010). PPP is concluded to be a valuable procurement mode that can mobilise private capital inputs, efficiencies and value additions to develop SI.

Having been used from centuries ago, but having seen fluctuations in popularity and usage; various levels of success worldwide; hence the need for more Research & Development (Akintoye et al., 2016; Akintoye and Kumaraswamy, 2016), PPPs are again considered as one of the mainstream models in the provisioning and management of public infrastructure in many countries (Badasyan and Riemann, 2019). A common definition for PPPs cannot be uniquely specified due to the differences in terms of legal, financial, political, economic, cultural and industrial backgrounds by countries and organisations (Zhang et al., 2016). According to Olusola et al. (2012), "PPP is a partnership between public sector organizations and private sector investors and business for the purpose of designing, planning, financing, constructing, providing and/or operating infrastructure, facilities or related services" (p.214). Pellegrino and Costantino (2019) defined Public-private partnership (PPP) as a widespread tool that government can employ to deliver public infrastructure, which uses private sector innovation and expertise, and often leverages private finance.

A PPP is based on a contractual agreement between a public-sector authority and a private consortium to procure and provide public goods and services (Amadi et al., 2018; Sharma and Bindal, 2014). Public-private partnership (PPP) is a widespread tool leveraging the government and the private sector, where the government can employ to deliver public infrastructure, which uses private sector for funding, innovation and expertise (Pellegrino and Costantino, 2019). The importance of PPPs has grown with the ideologies and needs of the time and place for various governments and stakeholders (Kumaraswamy et al., 2007). According to Buso and Stenger (2018), "PPPs may allow the public regulator to be more actively involved in a bargaining process with the private agent for decisions concerning the level of investment and the cost-sharing scheme" (p.490).

Taking specific examples applicable to SI, PPP inputs in the transportation sector, in providing utilities and in the communication sector have been significant. PPPs have received a growing attention in many countries recently as an innovative approach for delivering transportation infrastructure (Chen et al., 2016; Sinha and Jha, 2019). In developing SI, governments require private sector support, since the deployment of technology and equipment is often efficiently done by the private sector (Deloitte, 2016). Smart street lightning, self-monitoring corrosion controls in bridges, parking by sensor-aids, smart motorways and smart road cones are some of the smart applications in the development of transportation infrastructure (Pocock, 2019). These particularly benefit from PPP for attracting funding and in inspiring 'high-tech' innovations. In utility supply, smart sensors can help to reduce the energy consumption (Pocock, 2019). Moreover, the ICT sector is largely involved in enhancing smart communications in the modern world. The above examples indicate particular sub-sectors, where PPPs are establishing their value in SI development.

3.4 Adoption of PPP Models in SI Development

Moving to implementation, there are several examples in the application of PPPs in SI development. Also, different countries are developing different PPP operational models to suit their contexts (Fu, 2018; Li et al., 2015). Primarily, more research studies on SC/SI have been carried out in the developed countries, while emerging technologies are evident in developing countries. These developments enable the 'smart growth' of infrastructure (Medvedev et al., 2015). According to Vu and Hartley (2018), cities in developing countries are increasingly embracing pilot projects to experiment with a variety of applications, from traffic and waste management systems to e-governance and citizen participation, as needed for SC development.

Moreover, these SI development projects are often carried out in collaboration with the private sector. The following case examples are reviewed in order to identify important challenges faced in the adoption of PPP in SI development in both developed and developing countries.

Case examples in developing countries

The need for smart initiatives in the energy infrastructure and economic growth in the last decade has triggered the acceleration of SI development projects in Vietnam. Complex and competitive high-tech industry and decisions on capital investment are considered as important factors in such a context (Nguyen and Ha-Duong, 2009). According to Ha and Fujiwara (2014), neither the government nor the private sector is able to fund the entire infrastructure system because of the risks in terms of uncertain return from investments. In such situations, the government must create a fairly competitive market for attracting private corporations from foreign investors in this project (Roshchanka and Evans, 2016). A case study of SI development in India stated that conflicts between existing operations in a PPP project pose a significant threat to PPP and illustrate the importance of developing relevant policies by the government (Dolla and Laishram, 2018).

Learning, adaptation and innovation by utilising smart initiatives, which will design a better living environment for citizens is a priority in Croatia, as a developing country aspiring to SI development. Though, there are challenges in SI development in the development of capacities, capabilities, funding, governance, development of infrastructure and bringing new technology,these challenges could be overcome through PPPs, hence Milenković et al. (2017) identified PPPs as the ideal solution in developing SC projects in Croatia. This further illustrates how PPPs could help enable and accelerate the development of SCs.

Cases examples in developed countries

Italy was recently claimed to be the European country with the highest number of SCs (Dameri et al., 2019). They added that Italian SC initiatives are managed by municipalities, which have low financial resources. Therefore, Italian SC governments aim for partnerships with the private sector to overcome the challenges in securing funding. The SCs in Italy have started on a rapid growth trajectory with the introduction of policies enabling sustainable and resilient cities. According to Dameri et al. (2019), the Chinese mainland SCs are directly funded by the central government. On the other hand, many ICT firms and other private sector organisations aim for partnership with for example, the Shanghai municipal government, to accelerate the construction of this city as a global science and technology innovation centre (Zhang et al.,

2017). The requirement for managing the cities amidst rapid urbanisation has accelerated the leadership of the Chinese government in developing SCs (Dameri et al., 2019).A study by Lam and Yang (2020) in Hong Kong revealed that appropriate representation of the stakeholders is essential in developing an optimal procurement mode in SC development, since different SC projects have diverse characteristics,

Challenges and counter-measures in adopting PPPs in SI projects

The above case examples illustrate the drivers and potential benefits from deploying PPP in developing SI, as well as SCs themselves. Though there are many advantages of PPP in built infrastructure development, profound challenges could be encountered due to complex decision making, poor risk management, low transparency and lack of competition in market (Kwak et al., 2009), since participation may be limited to 'big players' from the private sector. Different PPP modalities have been used worldwide for SI development, with diverse results. As described by Zhang (2005), varieties of problems have been encountered in executing various PPP models. Lack of information and knowledge in the private sector in developing countries was seen as a barrier to implementing PPP in developing countries (Sharma and Bindal, 2014). Moreover, the selection of suitable partners for the SC projects can be identified as another major challenge (Sandulli et al., 2017). According to De Oliveira and Pinhanez (2017), barriers to adopting PPP in SC projects include high risk in investing in innovative solutions, uncertainty in policies and long-term delays before reaching profitability. As a consequence, major barriers to adopting PPP in SI development can be summarised as complex decision making, uncertainty in the industry, uncertainty in policies, ineffective risk management, low transparency, lack of information and poor selection of suitable partners. Given these challenges to PPP in SI development, a mix with non-PPP procured SI is needed (Uppenberg et al., 2011).

Olusola et al. (2012) discerned that transparency in the procurement process, competitive procurement process, good governance, well organized and committed public agency, social support, shared authority between public and private sectors, favourable legal framework, appropriate risk allocation and risk sharing, commitment and political support, are required for a PPP project to succeed. As discussed by Ahmadabadi and Heravi (2019), SC projects differ from conventional projects and effective risk management, fulfilling output specifications, reliable and quality service operations, adherence to time, supplying the demand for public facility/ service, profitability, and long-term relationship and partnership are the main success

factors in adopting PPP in SI development. Wu et al. (2018) found that effective risk management helps with better implementation and enhanced efficiencies of PPPs.

Furthermore, diverse PPP models of procurement, including in financing arrangements have emerged to address these challenges. According to Lam and Yang (2019) and Nguyen et al. (2019), the differences in PPP models are also needed to address the different characteristics in SC and SI development projects. Turina and Car-Pušić (2006) stated that, service contracts, operation and management contracts, leases, concessions and Build-Operate-Transfer (BOT) contracts and their variants are identified by most literature as the PPP models. As depicted in the study by Percoc (2014), management and lease contracts, concessions (public ownership and private ownership of the facilities), greenfield projects and divestitures are the types of PPP in infrastructure development. Nguyen et al. (2019) identified business-as-usual PPPs, incremental innovation PPPs, Co-research PPPs and Ground-breaking innovation PPPs in another classification of PPP models used in SC or SI development, based on their primary function in that scenario. While beyond the scope and lengthlimits of this paper to drill into the various PPP types, these examples serve to demonstrate that different models have evolved to meet various challenges in diverse scenarios in SI development for SC as well. Also, according to Heravi and Hajihosseini (2011), infrastructure development projects in developing countries are more likely to enter into PPPs. Furthermore, it was observedthat, the drivers for PPPs vary from country to country according to the economic environment and political background (CICID, 2009). Therefore, it can be confirmed that different SC projects will require different PPP models that should be designed to suit their respective regions, priorities and conditions.

It was also confirmed that SI comprises both hard and soft infrastructure, which could be developed through PPP and Non-PPP procurement models. Figure 3 is developed to convey the proposed core of a framework illustrating the envisaged PPP, as well as non-PPP contributions to boost SI development, based on a structured summary of the literature review findings in terms of the imperatives and needs for SI, as well as drivers of PPP in addressing these needs. Here, imperatives for SI are identified upfront. Viewed through the ‘lens’ of these imperatives i.e. from the top of Figure 3, it can be identified that SI development is becoming a global necessity. Some of the barriers/ challenges to develop SI that have been identified in this paper, almost intuitively suggest that PPPs could address these better, e.g. with private sector financing, know-how and incentivised innovation. It is then postulated that there are challenges in adopting PPP in SI development and it is also envisaged that these challenges could be alleviated through boosting the identified drivers and strengths of PPP in SI

development. Moreover, Figure 3 also illustrates how SI development can be further boosted and accelerated by mitigating or overcoming the challenges and barriers faced by PPPs themselves, in SI development. However, Figure 3 also shows that non-PPP procurement models are also still needed: for projects not suited to PPP, e.g., from a public security viewpoint or a private sector viability viewpoint. The findings presented in Section 3.3 and 3.4 provide sound answers to the second review question in line with the objectives of the study.

Figure 3: Proposed core of a framework for envisaged PPP contributions to boost SI development

4. Conclusions

Achieving sustainable development, amidst issues emanating from rapid urbanisation, aggravates the conflicts and multiplies the complexities in managing modern cities. SCs are identified as providing optimal solutions to these issues. Therefore, the emerging demands for SCs and SI must be addressed 'smartly' for sustainable urban development. The systematic literature review and analysis presented herein enabled identification and classification of the imperatives for, and barriers to, SI development; and the potential contributions despite challenges, of PPP to faster and better value SI development. It was found that both developing countries and developed countries are already building partnerships with the private sector to improve the development of SI. Breakthrough technological innovations are usually initiated by private sector organisations, given fiscal and bureaucratic constraints of most governments. Furthermore, it was confirmed that, the drivers for, as well as barriers to, PPPs, vary from country to country according to their economic environment and political background. As a consequence, different PPP models are required in SI development to suit prevailing priorities, constraints and conditions of each country. Moreover, it was determined that even in the same country, different SC/ SI development projects have different characteristics and the type of PPP model and resulting contract may vary accordingly as well. A basic framework was conceptualised to map the above force-fields that must be understood and then leveraged in order to develop SI using PPP where useful, as well as non-PPP approaches where PPP is not appropriate. A suite of different PPP models may thus be needed, of which one set could focus on developed countries and the other for developing countries. The contribution of the developed framework is to provide a basic platform to initiate a sound understanding of the potential roadmap towards boosting SI development through PPP, where useful. This

framework could be further developed and refined through empirical findings based on specific investigations into potential enablers and barriers. The next phase of this study will aim to establish and then 'benchmark' a set of basic PPP models that would be more appropriate for developing countries in general; and later another set of basic PPP models that would be more suited to developed countries in general; so as to optimize and accelerate the future development of SI projects worldwide.

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