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PUBLIC-PRIVATE PARTNERSHIP IN THE CONTEXT OF SMART CITIES: REVIEW OF CONTEMPORARY LITERATURE

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Abstract

Previous studies have made critical contributions to the theory and practice of Public-Private Partnership (PPPs) in the context of smart cities. A literature review plays an essential role in supporting scholars to better understand the topic, helping researchers identify the boundaries of the current body of knowledge and research trends, and shaping future research. Therefore, this paper analyses the latest research developments in PPPs within the context of smart cities. It examines papers published between 2001 and 2019 and discusses the relevant trends regarding PPPs and industrial sectors in the context of smart cities. The paper reveals that innovation and co-research in PPP projects are the main trends recently.

Keywords

Smart cities; Public-private partnership; Literature review.

Introduction

With the advancement of information and communication technology (ICT) and the Internet of Things (IoT), the concept of smart cities emerged. Many cities around the globe, such as Barcelona, New York, and Toronto have adopted a “smart” approach to renovate and develop their urban systems. As an integral part of the “smart cities” initiative, cities’ core infrastructure systems integrate digital technologies to build intelligent buildings, transport networks, and water treatment plants. There is a growing trend of incorporating smart technologies and components in the design of new infrastructure and the upgrade of existing infrastructure. The need for developing smart infrastructure has been highlighted by users, regulators, and governments. As stated by the Royal Academy of Engineering, smart infrastructure enables information gathering and processing, and ultimately facilitate informed decisions. Cruz and Sarmiento (2017) further claimed that smart infrastructure allows efficient use of energy and resources and is intelligently responsive to changes in the environment. Building smart infrastructure can be seen as an effective mechanism to facilitate effective and efficient delivery of infrastructure and its associated services.

PPPs have been widely used in infrastructure development and delivery. PPPs serve as important mechanisms to alleviate a government’s budgetary constraints, increase the service quality, reduce life-cycle costs and achieve optimum risk allocation. However, smart cities and smart infrastructure development have their characteristics and requirements, and traditional PPP models may not be suitable for these types of projects. For example, since the innovation in smart infrastructures, such as software and hardware gathering and processing big data, the private sector, acting as a technology provider, will leverage the big data for commercial use. If traditional PPP models are adopted, the public safety issue could arise because of the disclosure of public information and data to a private sector partner. It, therefore, remains uncertain whether the existing PPP models can be used in smart infrastructure development to accommodate the special characteristics and requirements of these types of projects. This paper conducts a critical literature review of PPPs in the context of smart cities based on papers published from 2001 to 2019 to answer the research question: what is the development status of PPPs in the context of smart cities?

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This paper begins by discussing the fundamentals of smart cities and PPPs. It then goes on to present the research method that was adopted. The following sections review selected publications under different types of PPPs applied in the context of smart cities. A brief discussion is presented after that, with the final section of the paper concluding and making suggestions for future studies.

Background

Smart Cities

Due to the rapid evolution of smart cities, there is no consensus on the definition of *smart cities* (Stone et al. 2018). The smart cities concept proposed by Giffinger and Gudrun (2010) includes a wide range of aspects in cities' development, such as smart economy, smart people, smart governance, smart mobility, smart environment, and smart living. There are also diverse smart domains included, such as smart infrastructures and behaviour communities (Rantakokko 2012). The concept of smart cities has also been mentioned in the context of public engagement and government, for instance, for cities developing web-based and technological methodologies to increase public participation in discussions (Diaz-Diaz & Perez-Gonzalez 2016). Deakin and Al Waer (2011) suggested that smart cities can be defined by the application of diverse technologies to transform life and working environments in cities.

Cities can be seen as smart when investments in the human and social capital, and traditional and ICT-based infrastructure, fuel sustainable economic growth and high quality of life, with a wise management of natural resources, through a participatory government (Rantakokko 2012). There are also different definitions of smart cities, for instance, Rantakokko (2012) stated that smart city is often defined as one with spatial intelligence and innovation, based on sensors, embedded devices, large data sets, and real-time information and response. Being a smart city brings new and better services to individuals, as well as cost savings to the city in the provision of services and operating the city (Rantakokko 2012). Most people agree that smartening of cities involves innovation in energy management, mobility services and practices, building design and management, health-care design and management, infrastructure development and use, technology implementation and governance and citizen knowledge and behaviour (Stone et al. 2018). Given the development speed of new technologies, the smart city is best considered not as an end-point but an unending process (Stone et al. 2018).

The smart cities approach being applied in city planning is a current trend, and two possible approaches may provide a methodology to move smart cities implementation forward: the technology-driven method and the human-driven method (Kummitha & Crutzen 2017). There is a consensus that a technology-based "smart" approach is fundamental to overcome the challenges of urbanisation (Cruz & Sarmiento 2017). The human-driven method is that smart cities are for individuals, and these people make their cities smarter. Smart cities also attract more key stakeholders to the city, such as companies, professionals, students, and create new business opportunities (Rantakokko 2012). The existing stakeholders, for instance, local government, citizens and businesses, living labs, and research and technology communities, have different roles in contributing to the development of smart cities (Rantakokko 2012). The involvement of these key stakeholders plays a critical role in making smart cities, especially regarding attracting funds and knowledge. Dupont et al. (2015) stated that urban sustainability needs efforts to enhance human dimensions collaboratively. It seems innovative sustainable solutions need innovative collaborations. PPPs can be seen as one of the critical aspects of smart cities.

Public-Private Partnerships

PPPs are most commonly used as a mechanism to leverage private funding to compensate for a loss in public funding based on the theoretical principle that private sector expertise can increase efficiency and cost reductions in public services (Cruz & Sarmiento 2017).

Regarding PPP model, for a project, the private sector calculates the required capital expenditure (CAPEX) and operating expenditure (OPEX), and it also estimates revenue, which is facilitated by the existence of several existing similar systems. The level of project risk is measured; then, the model calculates the expected return (Cruz & Sarmiento 2017). The design, structuring, and assessment of PPPs are based on an estimation of revenues, costs, and a risk assessment to determine a risk-adjusted return on investment. One of the advantages of the collaboration of the private sectors is reducing CAPEX and OPEX. However, the cost of private finance is often higher than public borrowing, whereas the efficiency of construction is to be expected, decreasing the overall CAPEX. Depending on these estimations, a project's net present value and internal rate of return – which are the most commonly used decision-making criteria – can be calculated (Cruz & Sarmiento 2017). Based on the project risk level and revenues, the private sector often requires some guarantee mechanism from the public authority to minimise the risk in case of insufficient revenue and potential bankruptcy. In the scenario when the real demand or consumption is lower than a threshold level, compensation from the public is required. In some scenarios, the PPP remuneration mechanisms do not require any demand risk; and the private sector is paid a fixed sum depending on the availability of the infrastructure or service (Cruz & Sarmiento 2017).

The PPP model has both potential benefits and drawbacks. A number of potential benefits can be listed: 1) the possibility of an overall decrease in life cycle costs, due to the bundling of different stages of the project; 2) the ability to leverage private capital to finance the construction and operation of public infrastructure; 3) freeing-up public resources that can be used for alternative investments; 4) allowing the government to focus on its core functions; and 5) promoting innovation and gathering the best available know-how from private international operators (Cruz & Sarmiento 2017). However, PPPs do have a high value of risk, especially when taking into account the negative effects of ex-post renegotiations, which occur when new circumstances appear, such as lower-than-expected demand, a change in the project design by the government, or fiscal and legal changes (Cruz & Sarmiento 2017).

The PPP model is one of the four critical key drivers of smart cities (Veselitskaya et al. 2019). These key drivers include mature infrastructure, wide use of ICT, the involvement of citizens in the city development, and the expansion of PPPs. There are a number of studies that emphasised the importance of reforming the traditional PPPs to support smart cities (Dupont et al. 2015; Cruz & Sarmiento 2017). A number of specific networks were reported (Dupont et al. 2015), for example, the university partnerships for co-designing and co-producing urban sustainability.

Research method

There are two stages in the review process in this paper, including paper collection and content analysis. The paper collection stage was guided by the collection protocol (Table 1), which presents information about the criteria's inclusion and exclusion and search strategy (Jasinski et al. 2015; Nguyen et al. 2018). The content analysis allows authors to identify the focused subjects (Elo & Kyngäs 2008). This section also highlights overview information regarding the collected papers, for instance, 1) the number of publications per year and 2) the reported countries and industrial sectors that adopt PPPs the most in the context of smart cities.

Paper collection

Table 1 shows the inclusion/exclusion criteria and a literature survey. The inclusion and exclusion criteria were identified based on review questions that represented the objectives of the literature review. Only peer-reviewed papers were collected for this comprehensive literature review. The review had only studies reported in English, and it minimised the risk of language bias in the results (Pickering & Byrne 2013; Nguyen et al. 2018). ISI Web of Science and Scopus databases were used to search papers because both of them cover the major literature sources across the different discipline areas and fields (Thomas 2014). The keyword search terms were 'smart city', 'smart cities', 'PPP', and 'public private partnership'. The timeframe for searching was not limited but was later revised to 2001–2019, as the

earliest paper that satisfied the research rules was 2001. In total, there were 56 collected papers, of which 21 were from Web of Science and 35 were from Scopus. Among these papers, some of them were overlapped. To eliminate duplicated papers, all papers' references (56 papers) were collected and stored in EndNote. By doing so, the duplicated papers could be easily eliminated, resulting in a total of 44 papers. In addition, a number of collected papers did not satisfy the research rules. For instance, some only had a title and an abstract in English, and others were not referred papers. Those papers were removed, which left a total of 32 for analysis.

Table 1: Collection protocol designed for the literature review process (Adapted from Nguyen et al. (2018))

Step	Research method
Inclusion criteria	Population: Peer-reviewed papers representing the PPPs and smart cities Language: English
Exclusion criteria	Editorials and book reviews
Searching the literature	Method: Database searching Databases: ISI Web of Science and Scopus Terms for searching: 'PPP' or 'public private partnership' and 'smart cities' or 'smart city'

Content analysis

This literature review adopted content analysis, which is a systematic and structural process to identify the main research themes for literature reviews. Content analysis allows scholars to examine huge quantities of documents in a systematic manner for identifying the focused subjects (Elo & Kyngäs 2008).

Overview of collected papers

There has been an increasing trend in the number of publications in the last four years (2016 to 2019), indicating a significant growing research interest in the topic of PPPs in the context of smart cities (see Figure 1). This growth may reflect an increasing number of PPP projects regarding smart cities, as the PPP model is one of the key drivers of smart cities (Veselitskaya et al. 2019).

Interestingly, the implementation of PPP projects in the context of smart cities was mostly reported in the EU countries, including Finland, France, Spain, Denmark, Italy, Netherlands, Belgium, UK, and Austria. In terms of country frequency, the top country which reported adopting PPPs into smart cities is Italy, following by the USA and Spain (see Table 2).

From the review, it appears that there is a diversity of industrial sectors that have adopted PPPs in the context of smart cities (see Table 3). *Infrastructures* and *ICT* are the fields in which most PPP projects are being reported, followed by *health* and *services*. The infrastructure includes housing, water, and transportation (bus, railway, and electric vehicle). ICT includes IoT, social media, IT-based product and services, data, and information management. The services include parking service, waste removal/recycling, smart garbage collection, public service improvement, banking, urban mobility, and mobility as a service.

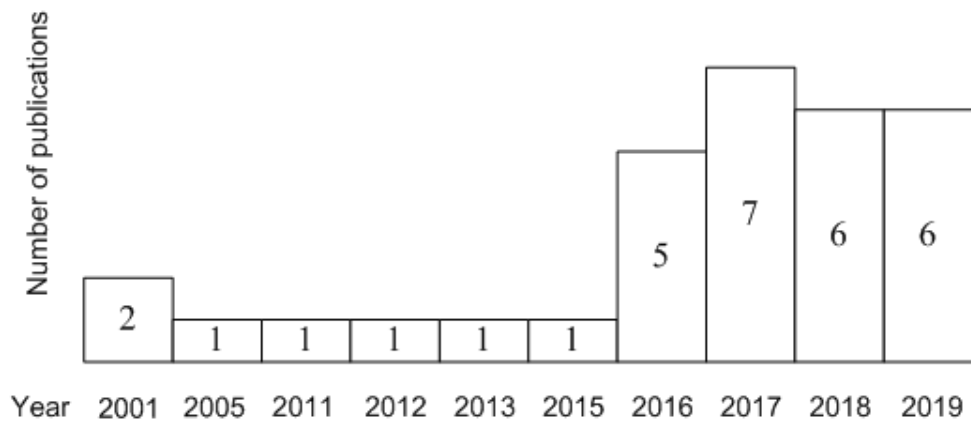


Figure 1: Number of publications per year

Table 2: Reported countries adopting PPP in the context of smart cities

No.	Countries	Number of papers	Percentage of papers (%) ¹
1	Italy	4	13
2	USA	3	9
3	Spain	3	9
4	UK	2	6
5	Finland	2	6
6	France	2	6
7	China	2	6

¹The total percentage does not equal 100% as only countries reported in more than two papers are shown.

Table 3: Industrial sectors

No.	Industrial sectors	Number of papers	Percentage of papers (%) ²
1	Infrastructures: Housing, water, transportation, energy	16	50
2	Information communication technology	15	47
3	Health	9	28
4	Services	7	22

²The total percentage is higher than 100% because a number of papers have more than one industrial sectors.

Literature review

PPP models in the development of smart cities

To illustrate how PPPs are being used in different levels of technological innovation, Cruz and Sarmiento (2017) classified three types for PPP development: business-as-usual PPPs, incremental innovation PPPs, and ground-breaking innovation PPPs. This classification is based on the level of innovation in PPP projects. In this paper, the authors classified the PPP projects based on four different types, business-as-usual, incremental innovation, ground-breaking innovation, and co-research PPP projects (see Table 4).

Table 4: PPP project classification

No.	PPP types	Authors
1	Business-as-usual PPPs	Farris (2001); Antonucci et al. (2015); Diaz-Diaz and Perez-Gonzalez (2016); Baruah and Gogoi (2017); Cruz and Sarmiento (2017); Anwar et al. (2017); Offenhuber and Schechtner (2018); Smigiel (2019)
2	Incremental innovation PPPs	Horan (2001); Snow et al. (2016); Dameri and Benevolo (2016); Cruz and Sarmiento (2017); Nesti (2017); Alvarez-Cedillo et al. (2017); Ferraris et al. (2018); Stone et al. (2018); Kim (2018); Selim et al. (2018); Grimaldi and Fernandez (2019); Smigiel (2019); Cooper et al. (2019); (He et al. 2019)
3	Co-research PPPs	Iida et al. (2005); Vinekar (2011); Rantakokko (2012); Dupont et al. (2015); Bull and Azennoud (2016); Abella et al. (2017); Ok and Yoo (2017); Kim (2018); Smigiel (2019); Veselitskaya et al. (2019)
4	Ground-breaking innovation PPPs	Ojasalo and Kauppinen (2016); Cruz and Sarmiento (2017)

Business-as-usual PPPs

Business-as-usual PPPs can be referred to as the standard PPP approach (Cruz & Sarmiento 2017). There are a number of particular PPP types, including 1) management and operating contracts, 2) leases, 3) concessions, 4) build-operate-transfer (BOT), 5) design-build-operate (DBO), and 6) joint venture (World Bank 2019). These generally involve long-term contracts and a significant level of financing by the private sector (Cruz & Sarmiento 2017).

It is noted that the classification of standard PPPs does not mean that there is no innovation in these projects (Cruz & Sarmiento 2017). However, the solution was used before and was essentially prescriptive, in which the public sector can determine, and specify the level of technological incorporation (Cruz & Sarmiento 2017). For instance, in 2014, the Land Transport Authority (LTA) in Singapore proposed a new bus contracts model to be able to provide a better response to ridership and commuter needs. The LTA owns the assets, such as vehicles and depots, and leases them to the operator; and the operators bid for the management of the system, and receive a fixed fee (Cruz & Sarmiento 2017).

One would expect that innovations regarding the smart sensing of infrastructure (e.g., in tunnels, pavements, or bridges), or in the signalling and management of Metro and rail operations, would be incorporated, as they can represent a gain in efficiency. However, the solution is essentially prescriptive, whereby the public sector determines, and specifies the level of technological incorporation that it expects, and in which systems and subsystems that innovation must be integrated (e.g. the Hohoot Metro

Line 1 in Mongolia). The systems are updated with tested technology but without a structural change in the level of development of such systems. The LTA is responsible for the planning of routes and services. The process includes a number of different packages. The first three included 5 year contracts plus 2 years extra for good performance; and the remaining nine have 2 to 10 year contracts (Cruz & Sarmento 2017).

Another example is the New Railway BOT – North-South Railway project – in the Philippines (Cruz & Sarmento 2017). The project is a 650 km new railway, which was launched in 2015, linking the Manila Metro (the capital region) with Legaspi City (capital of Albay province). The contract involves the design, construction, financing, operation, and maintenance of the system. The contract has a 34-year duration. (Cruz & Sarmento 2017).

Incremental innovation PPP

'Incremental innovation' PPPs can be referred to as a project that establishes PPPs for specific sets of subsystems, for instance, ticketing systems, vehicles, communication, and control system (Cruz & Sarmento 2017). The use of PPPs has been more related to 'hard' infrastructure development, for example, roads, airports, water systems, and dams. It is reported that there has been a growing trend towards increasing the use of PPPs in 'soft systems', especially information communication technology (ICT) systems. An example of this is the electronic ticket system in Athens (Cruz & Sarmento 2017). The PPP project aims to implement an integrated electronic fare system. The contract is for 12 years and includes the funding, design, installation, operations support, maintenance, and technical management of the system. The operator is remunerated through a payment mechanism linked to the quality of services (Cruz & Sarmento 2017).

Co-research PPP

Universities and research centres play an increasing role in an innovation project regarding smart cities (see Table 4). For example, the Oulu Innovation Alliance was established in 2007, consisting of the City of Oulu, the University of Oulu, the Oulu University of Applied Sciences, the VTT Technical Research Centre of Finland and Technopolis (Rantakokko 2012). The alliance' objective is to evaluate the city's potential from the global perspective to draw up a regeneration proposal for the Oulu innovation ecosystem in order to better meet the challenges of business and innovation (Rantakokko 2012).

Ground-breaking innovation PPP

'Ground-breaking innovation PPPs' can be referred to as a project that is more linked to isolated exploratory pilot actions, and the project proves the possibility of being able to test 'proof of concepts' (Cruz & Sarmento 2017). Ojasalo and Kauppinen (2016) referred to this type of PPP project as the creation or re-creation of new business. They stated that this option is initiated by companies and aims to create something new. It is supported by using cities as a platform for new ideas, where a plurality of stakeholders, ideas, and knowledge come together. The cities are a source of ideas and collaborative methods between systems and communities. New business opportunities come from innovative outcomes (Ojasalo & Kauppinen 2016).

Discussion

The literature review indicates that the previous studies focused more on the corroboration of different parties in the PPP projects as well as the innovation aspects of these projects in the context of smart cities, whereas the mechanism of PPP projects regarding the financial aspect in the context of smart cities is less discussed. This opens the door for future research. The further studies should pay more attention to develop a new PPP mechanism for smart cities where innovation is emphasised which create

more risks, and thus, the new PPP model should consider this aspect to balance the opportunities and risks for both public and private parties.

Even though PPP is one of the key drivers for smart cities, the public opinions are sometimes still sceptical about whether or not the private parties are making more profit on the existing public system than what they offer/benefit to the taxpayers. For instance, the incremental PPP projects are built up based on the hard systems that existed before, so the citizens will need to pay more to access these facilities because they now offer more convenience for them. However, the critical point here is how much the users are willing to pay for the new system. Even though this issue can be addressed by the transparency of PPP projects, people should keep in mind that the purpose of private parties is to make profits. Future studies should address these problems.

There is evidence suggesting that there is a requirement for different options for public services and their future innovation and production in the context of smart cities. Public-private–people partnerships (PPPP) is an increasingly popular approach for this purpose. Collaborative innovation enhances PPPP in general, which may bring many advantages to all individuals. It is critical for individuals to understand each other's concerns as well as their demands. The engagement has to be regular and open in nature in order to build trust (Ojasalo & Kauppinen 2016). Through the involvement of people in a PPP model, PPP projects in the context of smart cities will be more transparent and get more support from the citizens.

Conclusion

PPP in the context of smart cities has received attention from both academia and industry because of the increase in the demand of building up smart cities, while there is a shortage of public funding. This paper has presented a comprehensive literature review of PPPs in the context of smart cities, focusing on papers published from 2001 to 2019. The review aimed to advance understanding of this topic as well as highlight the current study status and trends. The review discovered the EU countries which have adopted PPPs in the context of smart cities the most. Infrastructures and ICT are where the PPP projects take place more commonly in developing smart cities. Regarding PPP project types, the incremental innovation and co-research PPP projects are the most commonly applied in the context of smart cities.

Some research trends for the PPP models in developing smart cities should be focused on. First, developing a new PPP model and mechanism will suit projects that require a high level of innovation. Secondly, public engagement in the development of an individual PPP project should be explored to create more transparency and trust among public and private parties.

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