

Applicability of Public-Private Partnerships in Smart Infrastructure Development: The Case of Hong Kong

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Abstract

Revamping infrastructure development with the best-emerging technologies and innovative procurement initiatives is seen as the optimal way forward to sustainable development, improved safety and health, performance and management of built infrastructure. The global COVID-19 pandemic has amplified these imperatives highlighting the global need for ‘smart infrastructure’. The needs for overcoming resource constraints suggest the increased potential for Public-Private Partnership (PPP) procurement strategy worldwide. Thus, this study aims to assess the potential for successful partnering between the public and private sectors in developing and sustaining ‘smart infrastructure’ in Hong Kong (HK). A qualitative research design was adopted, leading to ten expert interviews after a comprehensive literature review. The findings unearthed the potential enablers, barriers and enhancing factors, which were built upon regulatory, social, technical and political factors, affecting the adoption and success of PPP in delivering smart infrastructure in HK. An indicative framework was developed to illustrate the fundamental causal relationships of these factors. Through the findings, managing stakeholders, citizen-centric approach and maintaining transparency throughout the project, were identified as significant for the success. The research findings facilitate further studies along with pilot-applications of better-informed approaches to derive enhanced perceived benefits from PPP under appropriate conditions for smart infrastructure in HK.

Keywords: smart cities; smart infrastructure; Public-Private Partnership (PPP); Hong Kong (HK); developed region

Introduction

Cities are the main focal points of humankind living on this planet and utilising its resources. By 2050, two thirds of the world population was expected to be in towns, consuming over 70% of energy and emitting pollutants like greenhouse gases (United Nations, 2020). Even if this trend is quantitatively reduced after the pandemic, cities will still continue to become more complex as multiple human needs proliferate rapidly. Sustainable urban development is a widely discussed topic due to the urban complexities in the modern cities. New strategies using innovative technologies are seen as emerging necessities to face the increasing challenges from growing urban complexities. Besides, infrastructure modernisation is a major concern, even for existing infrastructure that warrants rehabilitation. This amplifies and accelerates needs for smart infrastructure. ‘Smart city’ is a broad term that encompasses a wide range of attributes, components, and dimensions (Desdemoustier et al., 2019). The lack of proper conceptualisation of the components underlying the essentials of a smart city, leads to some cities making questionable claims to be ‘smart’.

In HK, the expectation to develop smart cities and smart infrastructure is to address urban challenges, enhance effectiveness of city management and to improve people’s quality of living with the sustainable urban development (The Hong Kong Innovation and Technology Bureau, 2017). With the pandemic that started to spread globally in 2020, the importance of delivering smart infrastructure in rural areas has also become important, as some prefer to remain in, or return to suburban or even rural settings with less super-spreader infection risks. Therefore, nation-wide needs for smart infrastructure are emerging in both developed and developing countries to help improve life-styles both sustainably and safely, while doing so efficiently. Moreover, many local governments struggle to provide necessary public infrastructure in terms of both quality

and quantity to meet the needs of the society, which are aggravated by new urban challenges, under the budgetary constraints and vast spatial and economic inequalities (Offenhuber & Schechtner, 2018). Therefore, it is concluded that smart infrastructure development is a worthwhile concept warranting academic research for operationalisation in both developed and developing countries.

Unfortunately, many challenges arise when developing smart infrastructure, due to divergent stakeholder agendas, lack of resources, limited knowledge and competencies on both technological and governance/ managerial fronts, lack of citizen participation, political uncertainties and unstable/ unreliable funding structures (Jayasena et al., 2021a). Jayasena et al. (2021a), Selim et al. (2018) and Cruz and Sarmiento (2017), proposed that the application of Public-Private Partnership (PPP) can help to overcome such challenges in the development of smart cities/ smart infrastructure. However, it was identified that the enablers, barriers and the enhancing factors, which effect the success of PPP in smart infrastructure development projects differ according to differing conditions in a country. HK is a developed region, situated in East Asia, where rapid urban development is now coupled to sustainability targets. The HK government has also focused on developing smart infrastructure from the turn of this century. However, the slower than expected development of smart infrastructure, as well as a lack of research to develop sound enabling strategies, are noted in HK (KPMG, 2020). Even though, adopting PPP in smart infrastructure projects can be seen as a fruitful research topic to boost and guide the developments in HK, only few research studies including Lam and Wang (2020) have been conducted based on the context of HK. However, these studies also do not focus on smart infrastructure only but on the development of smart cities in general, i.e., a wider area with more variables. Hence, it is evident that identifying and developing basic possibilities, priorities, standards, frameworks and understanding in delivering smart

infrastructure in HK involving PPP, assumes more importance, especially after the outbreak of COVID-19 global pandemic.

This paper aims to explore the applicability of PPP in smart infrastructure development projects in HK. In order to achieve the aim, four (4) research objectives were lined up as: (1) Review the concept of smart city, the significance of smart infrastructure, and the importance of PPP in smart infrastructure development projects; (2) Explore the current status of PPP in the context of smart infrastructure developments in HK; (3) Investigate the ‘benefits and enablers’, ‘barriers’ and ‘recommended strategies and enhancing factors’, which may influence the success of PPP in smart infrastructure development projects in HK; and (4) Develop a basic indicative framework to enhance the understanding of the application of PPP in smart infrastructure developments in the context of HK. This study would benefit stakeholders and policy-makers in considering PPP for developing smart infrastructure in suitable scenarios. This also contributes to the growing body of knowledge in the domains of both PPP and smart infrastructure by unveiling the synergies when considering them together. The next section on literature review, is followed by a section on the findings of the expert interviews which are thereafter discussed in the context of the applicability and potential of PPP in smart infrastructure development projects in HK.

Literature Review

Smart infrastructure for sustainability

Smart infrastructure has specific characteristics and connectivity through ICT usage, which helps to accelerate the journey towards economic, environmental and social sustainability (Hollands, 2020; Caragliu et al., 2013). According to Martin et al. (2019), development of smart infrastructure is critical to achieving sustainability, where the

implementation of smart initiatives leads to digitisation of urban infrastructure to enhance connectivity and processes to provide improved quality of life for the citizens and to be more environmentally friendly at the same time. Six (6) main components, which are smart economy, smart people, smart governance, smart mobility, smart environment, and smart living (Nicolas et al., 2021; Kirimtat et al., 2020; Giffinger & Gurdun, 2010) have been identified in the previous literature. HK's smart city blue print also reveals that HK is also considering these six main components in delivering smart cities. However, lack of proper and/or complete conceptualization of these components and their implications, lead to misunderstandings of the 'smart' concept. Therefore, it is useful to identify the basis of these six main components under the 'smart' concept.

According to Kumar and Dahiya (2011) and Chourabi et al. (2012), innovation, entrepreneurship, trademarks, productivity, labour market flexibility, and integration in the national and global market are all aspects that contribute to economic competitiveness in the 'smart economy' i.e. the first component proposed above. As explained by Sun and Poole (2010), people in smart cities should connect and communicate with one another to share common and essential online social experiences as well as physical space, where the concept of 'smart people' (second component above) is illustrated. More importantly, it has been identified that such people need to provide data to enhance the connectivity of the developed smart infrastructure and services. Through the application of emerging information and communication technologies (ICT) for governing, smart government can be seen as a foundation for building smart governance. In accordance with Pereira et al. (2018), 'smart governance' uses technologically advanced techniques and communication mechanisms, to improve decision-making through better collaboration among different stakeholders, including government and citizens. According to Scholl and Scholl (2014), smart governance can be thought of as the foundation for smart, open,

and participatory government. 'Smart mobility' has become an essential component due to the rising need of transportation and mobility with the rapid increase of the population (Brčić et al., 2018). Environmental sustainability is important in planning and designing mobility in smart cities. According to Kumar (2020), "since humans are one component of the environment and integrated, the 'smart living' that conserves the environment is the answer to the smart environment" (p.1). After considering the above-mentioned components, it can be seen that the ultimate goal of delivering smart infrastructure is to enhance the quality of life of the citizens. Therefore, various high-tech applications and sustainability concepts are used for enabling smart living. It can be concluded that the development of institutional infrastructure, physical infrastructure, social infrastructure and economic infrastructure are all significant under the concept of smart infrastructure.

Other than in smart cities, smart infrastructure is needed and being developed in rural areas as well. With the COVID-19 pandemic situation, a growing escalation of needs for developing smart infrastructure in the rural areas arose to help rural communities in the rural areas as well, to maintain and monitor social distancing measures, and to help in identifying and tracking close contacts, while minimising disruptions. According to Cowie et al. (2020), positive benefits arise for society, in both urban and rural areas, by deploying modern technology to develop smart infrastructure. The importance and the applicability of smart infrastructure has been discussed in previous research like Bilbao-Osorio and Rodriguez-Pose (2004) and Berdegué et al. (2015). Naldi et al. (2015) has also described the importance of developing smart infrastructure in rural areas to help reach growth targets in a country. However, according to McCann and Ortega-Argilés (2013), concepts such as embeddedness, relatedness, and connectivity are well suited for intermediate rural areas that are integrated with urban areas. Therefore, in implementing smart infrastructure in the rural areas, the needs and wants of the community should be

taken into consideration. As rural areas have different socio-economic conditions and social structures, their problems and access to resources will be different from the society in the urban areas (Bilbao-Osorio & Rodriguez-Pose, 2004). Accordingly, it can be determined that the rural community's willingness to invest time and capital to improve their 'liveability', may differ from the community in urban areas. However, development of smart infrastructure will improve their quality of life as well.

Figure 1 presents a framework developed in a study by Berglund et al. (2020), which illustrates the significance of smart infrastructure. This is because of the more user-friendly mechanisms in smart infrastructure, allow the governing and administrative bodies to monitor, access, and control infrastructure services and environmental resources. It can be seen that there are many enabling technologies in smart infrastructure that help in managing the infrastructure services more sustainably. Moreover to Berglund et al. (2020), smart infrastructure is an ideal solution for facing the challenges associated with ageing infrastructure and increasing demands.

[Figure 1: Enabling technologies in smart infrastructure, allowing the governing and administrative bodies to monitor, access, and control infrastructure services and environmental resources (Source Berglund et al., 2020)]

The second row cylinders in Figure 2 illustrates a vast range of infrastructure, which could be developed and sustained under the 'smart infrastructure' imperative and on the considerations in delivering smart infrastructure. From Figure 2, it is evident that national level, provincial/regional level and local level priorities should be considered and integrated before developing smart infrastructure, since consistent country-wide policies and implementation strategies are important.

[Figure 1: Dimension layers/elements of horizontal and vertical integration of governance in smart cities (Source Ogra 2020, p. 66)]

The flow of benefits from smart infrastructure is clearly presented in Figure 3 based on that from Rice and Martin (2020), where the importance of smart infrastructure and the significance of the policies and strategies in delivering smart infrastructure are also indicated.

[Figure 2: Flow of benefits from smart infrastructure (Source Rice and Martin 2020, p. 8)]

From the concepts, frameworks and models presented, it can be confirmed that developing smart infrastructure is a growing need to achieve sustainability and to improve the quality of life of the citizens.

Current status of smart infrastructure development in developed countries

The previous section revealed that infrastructure provides the foundation for everyday life. Infrastructure enable the flow of goods, information and services within urban and regional settings (Rice et al., 2010; Ogie et al., 2017). The potential benefits of smart infrastructure include decreased maintenance costs, reduced damage and disruption costs (traffic congestion or power blackout), increased quality and value of service (on-demand use and flexible tariffs), as well as protecting human life e.g., less road accidents and/or faster and better response to disasters; all these benefits contribute to sustainable urban growth (Morimoto, 2010). These potential benefits from smart infrastructure, are prompting governments and local authorities across the globe to consider developing smart infrastructure. Cruz and Sarmiento (2017) indicate that smart infrastructure is being developed in many developed countries and governments are planning to implement more smart initiatives to upgrade the quality of life of their citizens.

As explained by Mboup (2017) also, it is assumed that development of smart infrastructure gains more attraction in developed countries as they improve the liveability

of a city. For example, Macomber (2016) stated that smart city technologies will be important to deploy across existing physical infrastructure, such as roads and buildings, or service utilities in developed countries. HK is a developed region, which aims in ‘developing smart’, by formulating and deploying master data management solutions to unlock the value of big infrastructure data for smart, sustainable and resilient city planning (Lee et al., 2010). As elaborated by the HK Innovation and Technology Bureau (2017), the HK government has: (A) taken many actions in implementing smart initiatives targeting smart economy, smart people, smart governance, smart mobility, smart environment, and smart living; and (B) provided faster payment systems, electronic health record sharing systems, smart initiatives in accident and emergencies, support for the elderly and persons with disabilities in enhancing smart living of the citizens. Environmentally friendly transport systems, such as foot-cycles have been promoted and intelligent transport systems and traffic management systems have been implemented to upgrade smart mobility. Smart initiatives have been also introduced for pollution monitoring and waste management techniques to work towards a smart environment. Hence, there is a clear need for developing standards and frameworks to build smart infrastructure that are functional and sustainable.

Application of PPP in Smart Infrastructure Development Projects in Developed Countries

As explained by Ke et al. (2010) and Sun et al., (2020), many public smart infrastructure service projects in China and elsewhere have recognized PPP as often the best approach in delivering infrastructure under certain conditions. According to Cruz and Sarmento (2017) and Jayasena et al. (2021a), PPP is frequently employed in smart infrastructure construction around the world since it is thought to benefit the public sector, private sector, and eventual consumers. Furthermore, the above authors identified the application

of PPP as suitable for both developed and developing countries. In their discussion on the success factors for PPP, Zou et al. (2014) identified the importance of effective communication, commitment and participation, disseminating the objectives, benefits and implications of the project and defining the value objectives. Tiong (1996) identified the importance of leadership and selection of the right project among the success factors of PPP.

There are some examples in other countries, where PPP was deployed in smart city developments. For example, the urban revitalization project of the Port Zone is considered as one of the biggest PPP projects in Brazil. This project deployed a smart service platform upgrading the transport, residential and commercial areas and the ICT infrastructure (Schreiner, 2016). In this PPP for smart city project, a long concession contract was structured and implemented to assure a low risk to the investors regarding the impact of the political risk and also considered engagement of the citizens as an important factor. As another example, Barcelona in Spain has implemented an initiative to a smart city project, which is to integrate the IT network and to enhance the connectivity. This was conducted as a PPP project to pool public and private sector resources efficiently, with an initial contract period of eight years. Commercialization of the remaining capacity of the network and Wi-Fi premium services was implemented as a method for return for the investment (Salvador et al., 2017).

Roehrich et al. (2014) explained that the World Bank (2010) identified six PPP contract types suitable for infrastructure development as, service contract, management contract, lease, concession, Built-Operate-Transfer (BOT) and divestiture. Moreover to Roehrich et al. (2014), contract types can also be classified from the view of project characteristics. For example, Yang et al. (2012) pointed out that existing projects can be procured in module outsourcing, and sale/leaseback lease/purchase contract type, while BOT, Toll-

Operate-Transfer (TOT) and privatisation can be applied for a new project. Further, the level of private sector involvement contributes to the classification of PPPs. Accordingly, Operation and Maintenance (OM), Build-Finance (BF), Design-Build-Finance-Maintain (DBFM), Design-Build-Finance-Maintain-Operate and concession (such as BOT) have been identified as the main PPP contracts. As explained by Yang et al. (2012), Cruz and Marques (2011) and Turina and Car-Pušić (2006) the types of PPP according to the level of private sector involvement are, BOT, Build-Own-Operate (BOO), Build-Own-Operate-Transfer (BOOT), Design-Build-Finance-Operate (DBFO), Design-Build-Finance-Maintain (DBFM), Design-Build-Finance-Maintain-Operate (DBMFO), Design-Construct-Maintain-Finance (DCMF), Design-Build, Design-Build-Finance and O&M (Operation & Maintenance). Hence, it is evident that there are different types of PPPs, which can be used in different smart infrastructure developments, according to the type of project.

Research Methodology

Qualitative studies can provide rich knowledge on novel or complex phenomena (Sharma et al., 2020) by providing detailed primary/ direct information. As explained by Chan and Choi (2015), Creswell (2014) and Dawson (2007), a qualitative approach is used to understand and explore individuals or groups in-depth opinions or understanding about any subject matter by exploring their experiences, attitudes and behaviours. PPP in smart infrastructure development is a complex phenomenon, where the applicability has not been investigated in-depth for HK recently. Yin (2011) explained that qualitative approach contributes to intensive exploration of emerging concepts through in-depth investigation. Therefore, a qualitative research approach was adopted in this study. Figure 4 diagrammatically summarises the principal research techniques and the corresponding

research objectives, which are translated into the study outcomes as presented in different parts of this paper.

[Figure 4: Research techniques, Objectives and research Outcomes presentation]

Data Collection

Initially a comprehensive literature review was carried out in order to review the concept of smart city and smart infrastructure, their significance and to investigate the importance of PPP in smart infrastructure development projects. Subsequently, a series of 10 semi-structured interviews among experts in PPP and/or smart infrastructure development were conducted through face-to-face or online modes to explore the current status of PPP in smart infrastructure developments in HK and, to investigate the ‘benefits and enablers’, ‘barriers’ and ‘recommended strategies and enhancing factors’, which could influence the success of PPP in smart infrastructure development projects in HK. As stated by Harrell and Bradley (2009), semi-structured interviews could be used when the researcher targets a deep investigation on the research topic. In this study, the semi-structured interview guideline consisted of open-ended questions, where the interviewees were able to provide their own experience and views on potential ‘benefits and enablers’, ‘barriers’ and ‘recommended strategies and enhancing factors’ affecting or which will affect the PPP involved smart infrastructure development projects in HK. In the guideline no previously identified factors affecting PPP in smart infrastructure projects were mentioned as to gather the essential factors based on the experts’ own experience and views. The expert interviewees were selected from a group of prominent academic professors and senior industrial practitioners who have already gained abundant research experience or working experience in PPP and/or smart infrastructure development projects through the snowball sampling technique as there are only limited number of relevant experts in HK, i.e., with

in-depth knowledge of the application of PPP in smart infrastructure development projects. A multitude of previous research studies in the construction management domain (e.g. Chan et al., 2007; Chan et al., 2011; Chan and Choi, 2015; Choudhry and Fang, 2008; Hatush and Skitmore, 1997) had conducted five to ten expert interviews and these numbers were perceived to sufficiently represent the respective populations under study. Hence, this research study adopted 10 interviews in the collection of data as well. Thus, the interview findings and rich insights derived from this study were considered representative and reliable in substantially covering the critical areas, as well as a representative population under investigation. Table 1 illustrates the profile of the interviewees as indicated by their designation, experience and the current work sector.

[Table 1: Profile of the interviewees]

Data Analysis

In qualitative research, content analysis technique is identified as one of the commonly used analytical techniques (Elo and Kyngas, 2008). Content analysis is a systematic and objective means of analysing written, visual or verbal messages (Cole, 1988; Sandelowski, 1995). In essence, content analysis enables the researcher to distil words into fewer content related categories (Elo and Kyngas, 2008; Chan and Choi, 2015), hence selected as the data analysis technique for the study. Fundamental concepts of the interview dialogues were duly analyzed and collated by content analysis that utilised a matrix table to capture any similarities and differences for cross-comparisons, aiming at determining the collective opinions (Chan and Choi, 2015). Hence, data captured through the expert interviews, were analysed using the content analysis technique to identify the benefits and enablers, barriers and the recommended strategies and enhancing factors affecting the success of PPP in smart infrastructure development projects in HK. Further,

by analysing and consolidating the findings from the literature review and the expert interviews, a basic indicative framework was developed to understand ‘PPP for smart infrastructure developments in HK’. The findings and a discussion of the findings are presented in the next section.

Research Findings and Discussion

The following sections present the findings and the discussion.

Current status of PPP in smart infrastructure development projects in HK

According to some of the interviewed experts, the development of smart infrastructure in HK has progressed over the last two decades. In contrary, some interviewees explained that while initiatives have been launched, followed by initial activities, HK has not yet formulated a holistic plan to encompass ‘all infrastructure’ or ‘infrastructure systems’ in HK: for moving them to ‘smart’ modalities. Most of the experts believed that more technology inputs are needed for delivering smart infrastructure in the country. The experts in these fields also felt that money is not a crucial barrier in developing smart infrastructure in a developed region like HK. However, the experts stated that PPP would be required for efficient smart infrastructure development projects in HK, i.e., to carry out and deliver projects more efficiently and effectively, with new high-tech smart applications. It was also acknowledged that the deployment of PPP in smart infrastructure development projects is only moving quite slowly in HK at present and more extensive PPP inputs could also accelerate smart infrastructure development itself.

According to the Efficiency Unit (EU) of the Government of HK, PPPs are "arrangements where the public and private sectors both bring their complementary skills to a project, with varying levels of involvement and responsibility, for the purpose of providing public services or projects" (Government of the HK Special Administrative

Region, Efficiency Unit, 2004). Moreover, it appears that PPPs are most likely to adopt the DBFO model or the DBO model in HK. Under DBFO, there is a concession agreement where the public sector specifies the outputs it requires from the PPP facility, the basis for payment for those outputs, and the risk-sharing arrangements. In that scenario, the private sector is involved in designing, building, providing core and/or ancillary operations services, maintaining, financing and sometimes owning the PPP facilities.

West Kowloon cultural district, Zero Carbon building and East Kowloon area, which are pilot smart city projects can be determined as few cases implemented PPP in smart infrastructure development. In these projects, smart applications such as smart lampposts and smart parking have been implemented. Smart parking technologies have been utilised in HK to monitor and reduce illegal parking. Moreover, it has been revealed that smart technologies and applications have been utilised in monitoring the structural stability of bridges and flyovers. As explained by interviewee I5_{HK}, monitoring the uneven settlements and vibration in flyovers is a significant application to ensure the safety of users. Another smart application in HK is for sharing health information of patients' between public and private sectors. According to the experts, this application is still in the initial stages of implementation in HK, where the area can be improved vastly.

Most of the interviewees explained that the transportation sector is being increasingly attracted to develop smart infrastructure using PPP in HK. According to I6_{HK} and I4_{HK}, the transportation sector is a more popular testbed for adopting PPP in the development as 'smart infrastructure' because these projects can receive direct income as the users pay operators directly, which is more profitable for the involved private sector party. Therefore, it is concluded that the direct 'user pay' model is more successful in HK. Moreover, the experts added that public interests should be considered closely, in

the development of smart infrastructure. As stated by I5_{HK}, the sectors, where smart initiatives should be applied must be identified as the first step in adopting PPP in delivering smart infrastructure. Hence, it can be seen that a realistic assessment of the long-term public demand is essential for the success of such PPP projects. Section 4.2 elaborates further on the benefits and enablers influencing the success of PPP in smart infrastructure development projects in HK from an overview perspective.

Benefits & Enablers for adopting PPPs in Smart Infrastructure Development projects in HK

All the interviewees have identified the importance of adopting PPP in smart infrastructure development projects in HK despite it being a developed region. Table 2 presents the benefits and enablers for adopting PPP in smart infrastructure development projects in HK.

[Table 2: Benefits & enablers for adopting PPPs in smart infrastructure development projects in HK]

Desire to reduce public sector costs

All the interviewees viewed the reduction of the budgetary constraints for the government to be an enabler influencing the success of PPP in smart infrastructure development projects in HK. Li et al. (2005) identified PPP as a suitable procurement strategy for constructions projects in the UK (a developed country), in reducing the public sectors' costs. According to the PPP experts in HK, PPP is not suitable for some projects, hence cannot be recommended for all types of projects in HK. According to these experts, PPP is not suitable for small-scale projects as these can be financed by the government, in a developed region like HK. However, smart infrastructure projects require higher than usual investments due to the deployment of smart applications within the infrastructure,

where this has been clearly explained by Adriaens et al. (2021). Therefore, the government may not be willing to divert so much extra funding from their capital budget for smart infrastructure developments. This suggests the need for involving the private sector in smart infrastructure development projects. Similarly, this translates to a significant benefit for adopting PPP in such scenarios.

Active government involvement and high experience of both public and private sectors in PPP projects

Five (5) out of the ten (10) interviewees agreed and stated that active government involvement is essential to enable the application of PPP in smart infrastructure development projects. Selim and ElGohary (2020) also mentioned the importance of the active involvement of the government in PPP involved smart infrastructure developments. According to interviewee I6_{HK} “*HK government aims on enhancing the quality of life of the citizens, and they partner with private sector to have a smooth implementation*”. Hence, it is confirmed that the active government involvement translates to a benefit in delivering smart infrastructure, because the public sector is the party, who usually initiates the infrastructure development projects. When the government is initiating smart infrastructure development projects and welcoming the ideas of the private sector, the private sector can actively involve in the projects. As some smart infrastructure development projects involving PPP have already been successful in HK, both private sector and public sector have the experience and knowledge regarding PPP as well. This high experience is advantageous for the success of PPP in the future smart infrastructure development projects in HK.

Efficient delivery and management of the project

According to the experts, private sector is seen as better project managers. Hence, the

engagement of the private sector in smart infrastructure development projects is seen to be a significant factor influencing the efficient delivery and management of the project. This has been identified by Jayasena et al. (2021a) through a systematic literature review. It is confirmed that this factor acts as an enabler for the context in HK as the experts believed that management skills and project management experiences of the private sector in HK can be mobilised in smart infrastructure development projects to deliver the project to the appropriate quality within the required timeframe and under an optimal budget.

Private sector innovativeness in smart technologies and need for advanced technological applications for smart infrastructure development projects

Experts in PPP and smart infrastructure development in HK explained that the technological knowhow of the public sector is generally not high, while more advanced technological applications are required in the development of smart infrastructure than in the development of normal infrastructure. All the experts agreed on the mounting necessity for higher technological advances in smart infrastructure development projects, where the private sector could inject new technologies and mobilise their technological skills in developing smart infrastructure in HK. This was identified by Liu et al. (2020) as a factor influencing the adoption of PPP in smart city projects, in general.

Higher risk in smart infrastructure development

As mentioned by an expert interviewee “*smart infrastructure projects will be fairly novel in HK and will require certain advanced technologies, higher risks would be expected*”. According to Selim and ElGohary (2020), complexity and high investment cost of smart infrastructure projects creates higher risk of development. Further, as the investment required to deliver smart infrastructure are higher than in traditional infrastructure

development projects, the financial risk is also higher. Engagement of the private sector in PPP for smart infrastructure development will lower the risk to each party and precautionary measures can be carefully taken mobilizing proper risk management practices among the parties involved in the PPP, hence identified as an enabler influencing the adoption of PPP in smart infrastructure development projects in HK.

Culture of the country

As stated by the interviewees, the culture of HK is generally favourable to applying PPP in smart infrastructure development projects. According to I10_{HK} “*the community is not resistant to changes for the better*”; and usually quite receptive to visibly beneficial or proven technological innovations hence can be an enabler influencing the success of smart infrastructure development projects. However, the experts emphasized the need for managing and carrying out the project in a transparent manner to earn the trust of the community for applying PPP in smart infrastructure development projects in HK.

Barriers to adopting PPPs in Smart Infrastructure Development projects in HK

Amidst the rising requirements of PPP in smart infrastructure development projects in HK, as in most breakthrough initiatives, barriers can also be identified to their application. Table 3 presents the barriers influencing the adoption of PPP in smart infrastructure projects in HK as obtained from the literatures and as confirmed by the interviews.

[Table 3: Barriers to adopting PPPs in smart infrastructure development projects in HK]

Reluctance of the public to accept private sector involvement in infrastructure development projects and unawareness of the public on advantages and importance of PPP

The experts revealed that there had been transparency issues/ questions raised in selecting

the concessionaires / ‘special purpose vehicles’ in many previous PPP projects in HK. As a result, many citizens had lost trust in the selection of private sector partners and the public is usually reluctant to welcome private sector involvement in smart infrastructure development projects in HK. This acts as a barrier to adopting PPP in smart infrastructure development projects in HK. In accordance with the view of all the experts, awareness of the public on the importance of PPP plays a key role in the execution of the project. Selim et al. (2018) and Jayasena et al. (2021b) have identified citizens as one of the most important stakeholders in smart city projects, where their concerns and engagement in the project significantly affect the success of the project. I9HK described that the public will be more interested and enthusiastic than in the current situation in implementing PPP in smart infrastructure development projects if they are aware of the context and on the net benefits and advantages of PPP.

Lack of policies and regulations

Six (6) out of ten (10) interviewees lamented a lack of policies and regulations in the execution of PPP in smart infrastructure developments. According to the expert interviewees, the requirement of developing new policies and regulations acts as a barrier to effectively engaging the private sector in smart infrastructure development in HK. As explained by the experts, more private sector ‘friendly’ policies and regulations should be developed in order to attract the private sector in the development of smart infrastructure.

Unfavourable financial structure

The return on investment for the private sector should be considered when deploying PPP in a smart infrastructure development project. Eight experts in the relevant fields have mentioned unfavourable financial structures in HK as a barrier influencing the adoption

of PPP in smart infrastructure development projects. According to this view of the experts, the private sector would be encouraged to involve more in smart infrastructure development projects if there is a favourable investor-friendly financial structure. More financial incentives and potential benefits can then be provided to attract private sector parties to developing smart infrastructure in HK.

Political instability/ political influence

Political influence in the projects, including in the tendering processes and in selecting the contractors can be considered a significant factor influencing the success of PPP projects. Moreover, the interviewees identified political instability and the social problems associated with political parties as creating unfavourable conditions in adopting PPP in smart infrastructure development projects in HK. Cruz and Sarmento (2017) also identified political influences as a major factor influencing the success of PPP in smart city development projects.

Recommended strategies and enhancing factors for improving PPPs in delivering smart infrastructure development projects in HK

The growing importance of implementing PPP in smart infrastructure development projects in HK has heightened the need for identifying the ‘enhancing factors’ that can influence the success of PPP in smart infrastructure development projects. Table 4 presents the enhancing factors identified through the expert interviews carried out in HK.

[Table 4: Recommended strategies and enhancing factors for improving PPPs in delivering smart infrastructure development projects in HK]

Effective management procedures of the PPP projects

Many researchers including Shrestha et al. (2017) have identified how PPP enhances efficiencies in the delivery of infrastructure. This was also conveyed by the interviewees.

The interviewed experts clearly stated that providing well-defined project objectives and the minimum specifications will provide the basic understanding of the expected project outcomes to the private partner. Thereby, the quality of the PPP project would also necessarily improve. Moreover the experts believed that the selection of the contractors should be fair, based on proper evaluations, and including of track records of the private sector candidates for PPPs as the selected partner would significantly influence the success of PPP in smart infrastructure development projects. Further, high transparency and accountability in the operational procedures of PPP projects will create confidence in the community. Being transparent in the procedures followed is identified as significant in demonstrating care and consideration on how the public feels. According to I3HK, sharing relevant information with the public in a transparent manner will be an enhancing factor, which influences the success of PPP in smart infrastructure development projects. To enhance the quality in PPP projects, it was identified that appropriate risk management procedures should be followed. Risks should be shared fairly between the public sector and private sector from the contract development stage. These effective management procedures influence the quality and success of PPP in smart infrastructure development projects in HK.

Enhancing public awareness of the project

Citizens in general are considered as an important stakeholder group in smart city projects as the developments are being carried out to benefit the general public (Nguyen et al., 2019). As explained by the interviewees, to build upon the trust and awareness of the community, effective communication strategies should be formulated and implemented. Describing the workings and outcomes of previous successful cases, which have implemented PPP in smart infrastructure development projects in HK and other developed countries, enhances the public knowledge regarding the importance of the

projects. According to I7HK, each step of the development project should be communicated to the public via newspapers, social media and other media, which are popular with the citizens. This can also be identified as an important step in stakeholder management process. Smart cities are identified as multi-stakeholder eco-systems and the public is said to be an important stakeholder. Therefore, enabling public engagement in the decision making process of smart infrastructure developments is identified as a crucial enhancing factor influencing the success of PPP in the projects.

Close monitoring and control

In order to improve the quality of PPP in smart infrastructure development projects in HK, the interviewed experts illustrated that close monitoring and control of the project is significant. The importance of monitoring and control in PPP projects, was mentioned by Poroshin and Studenikin (2020) as well. According to an expert “*monitoring the projects is a key for success especially in complex projects like smart infrastructure developments*”. To carry out close monitoring, periodic meetings and inspections would be needed. This will improve the quality of the project as unsatisfactory developments or smart applications can be discussed and improved according to the comments received. Moreover, incentives can be provided for the corrective actions in the project and bonuses or penalties can be deployed in accordance with the output of the PPP projects. Most of the experts in the relevant fields in HK stated that it is important to provide mechanisms for the government to control the delivery of the project, as the government is more concerned with the quality of the development and in enhancing the quality of life of the citizens. This would clearly improve the quality of the project and influence the success of PPP in smart infrastructure development projects in HK.

Figure 5 demonstrates the basic indicative framework developed through the

consolidation of findings from the research for this paper. It illustrates the ‘benefits and enablers’ and ‘barriers’ in adopting PPP in smart infrastructure development projects and the ‘recommended strategies and enhancing factors’, which could be leveraged for improving the efficiency and effectiveness of the urban and rural smart infrastructure development projects in HK. Hence, all these factors influence the success of PPP in delivering smart infrastructure in HK. Initially, an overview of some of these factors were identified through a comprehensive literature review. However, the views and opinions of the experts, which underpins the second step of the research, led to the identification of many factors, which have not been revealed or discussed in previous literature for the context of PPP and smart infrastructure developments in HK. Grouping of these factors was carried out as per the experts’ opinions as well, based on their hands-on experience in PPP involved smart infrastructure development projects in HK. This framework could be utilised as a basis in decision making, launching pilot projects which can be monitored for further study and in minimising unsuccessful PPPs in delivering smart infrastructure.

[Figure 5: Basic indicative framework of the factors influencing the success of PPP in smart infrastructure development projects in HK]

Conclusions

It is concluded that smart infrastructure needs have rapidly escalated after the shock-waves from the global COVID-19 pandemic as well as climate change impacts, in both urban and rural infrastructure. According to the views of the expert interviewees in PPP and/or smart infrastructure, synergising the concepts and potential mutual benefits from smart infrastructure and PPP is not new worldwide, nor novel in HK. Although not consciously pursued up to now, a few projects applying PPP in smart infrastructure development have already been carried out in HK, as discussed in the findings section.

However, HK has not moved as far as many other developed countries in the application of PPP in smart infrastructure development projects. Based on some lessons learned from already implemented PPP involved smart infrastructure projects in HK (West Kowloon Cultural District, Zero Carbon Building and Energising East Kowloon), the interviewees revealed many factors affecting the success of PPP projects in HK and in general too. Given the need for policy and regulatory support and incentives, certain barriers currently retard the uptake and/or success of PPP in smart infrastructure development projects in HK as mentioned in the research findings section. However, it can be seen that the positive influence of the identified benefits and enablers and through adopting recommended strategies and enhancing factors as discussed, will help to optimize the adoption of PPP in smart infrastructure development projects. It is evident that the stakeholders in smart infrastructure development projects are important contributors in a developed region like HK as well. Therefore, human factors should be well managed in order to achieve success of PPP in smart infrastructure development projects.

The benefits and enablers as presented, have already influenced and would thus boost the rationale and mounting pressures for applying PPP in smart infrastructure development projects in HK. As always, the application of PPP cannot be identified as a suitable strategy for all types of development projects whether in HK or elsewhere. As gleaned from the expert interviewees who have derived direct hands-on experience, small-scale projects and/or those not needing complex/ multiple and high-technology inputs may be handled and invested in by the HK government itself. Therefore, it is important to carry out feasibility studies before the application of PPP in smart infrastructure development projects. By utilising the recommended strategies and enhancing factors mentioned by the interviewees, the identified barriers may be overcome. It is seen that all the barriers identified in the context of HK can mostly be

managed through these recommended strategies and enhancing factors. Overall, it can be determined that the application of PPP in appropriate smart infrastructure development projects is suitable even for a developed country/ region, having the same conditions like HK. The findings of this study will help enhance and accelerate the development of smart infrastructure in HK and help improve the quality of living of the citizens, overcoming the challenges arise from rapid urbanisation. Since this paper unearths useful findings from a less researched area, especially in the context of HK, the basic indicative framework that was developed in this paper could be used as a basis in the planning and designing stages of the PPP implemented smart infrastructure development projects in HK, for in-depth identification of the influential factors and as a sound basis for decision making for the policy makers and project initiators, starting with some pilot projects with a strong focus on these essential factors.

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