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UNDERSTANDING THE RELATIONSHIP BETWEEN INFRASTRUCTURE PUBLIC–PRIVATE PARTNERSHIPS AND INNOVATION

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ABSTRACT: While the contemporary academic discourse regards innovation as an inherent feature of infrastructure public–private partnerships (PPPs), the conceptual link between infrastructure PPPs and innovation is narrowly understood. While most existing studies conceptualize the innovation processes and effects within the context of PPP projects, we argue that the relevance of innovation in infrastructure PPPs goes beyond specific projects. In this conceptual article, we examine why and how infrastructure PPP innovations can shape the evolution of the involved private and public sector organizations – and therefore the respective sectors – more broadly. We show that innovation in the context of PPPs has much broader implications and potential outcomes than as emphasized in the literature so far.

KEYWORDS: Public–private partnership, innovation, infrastructure

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1. Introduction

Innovation is often perceived as an intrinsic characteristic of private, finance-based infrastructure public-private partnerships (PPPs) (Yescombe 2007; Hodge and Greve 2018). It is widely argued in scholarly and practice-oriented literature alike that innovation is a likely outcome of the integration of design, building, financing, operations and maintenance tasks into a single contract, which incentivizes the private sector to develop innovative solutions for public infrastructure needs (e.g., Grimsey and Lewis 2005; OECD 2008; Brewer et al. 2013). In a similar vein, hardly any public sector innovation or reform strategies now fail to emphasize the importance of cross-sector partnerships as a source of innovation. According to Linder (1999), the upsurge of PPPs was inspired by and in accordance with the neoliberal focus on privatization and efficiency gains, often building on the assumption that the private sector is more effective and innovative than its public counterpart.

However, despite the increasing use of infrastructure PPPs worldwide[1] and increasing academic attention regarding innovation, the conceptual research into the relationship(s) between innovation and infrastructure PPPs remains limited (Leiringer 2006; Barlow and Köberle-Gaiser 2008; Himmel and Siemiatycki 2017). The existing studies have utilized various approaches, including economic behaviour models, industry practitioner surveys and case studies, to shed light on this complex issue (Himmel and Siemiatycki 2017; Brogaard 2018). Interestingly, the existing studies have limited their attention almost exclusively to PPP projects as such, largely neglecting the influence of innovation on the change processes in the involved organizations; that is, how innovations emerging from PPP projects contribute to the emergence and institutionalization of new capabilities in the involved private and

[1] In Europe alone, on average EUR 19 billion EUR worth of PPP transaction deals were closed annually in 2000–2016. See http://www.eib.org/epec/ (as of 7 April 2017; authors' calculations).

public sector organizations and how these new capabilities induce wider evolutionary changes in the private and public sectors – and subsequently in society more broadly. This is a crucial issue, as PPP projects can be seen as potentially important learning environments capable of catalysing changes that have a significant impact beyond specific PPP projects. Importantly, innovation impacts often have negative consequences (Soete 2013), an aspect that should not be underestimated in the context of PPP projects. Nevertheless, these broader aspects of PPPs and innovation have largely gone unnoticed in the existing literature.

The aim of the current article is threefold. First, we aim at bringing together the different innovation logics that are not limited to the context of PPP projects, applying also to the private and public sector contexts. Second, we aim to demonstrate how the different innovation-contextual logics are related to the typical stages in infrastructure PPPs. While linking PPP stages to innovation is hardly novel (see, e.g., Barlow and Köberle-Gaiser 2008), our goal is to show how the specific PPP stages can potentially induce innovation that reaches beyond the projects themselves. In so doing, we can show that innovation in infrastructure PPPs has much wider implications and potential positive and negative outcomes than as previously emphasized in the literature. Finally, by grounding the understanding of innovation and PPP more firmly in the logic of three contexts of innovation, we offer a conceptual framework that embeds the PPP concept more firmly in the contemporary innovation literature.

In the next section of the paper, we provide a short overview on PPPs and their general relationships with innovation before zooming in on the specific aspects of infrastructure PPP innovations by focusing on three contexts: PPP projects, private sector and public sector. We then proceed to present a taxonomy explaining how the wider innovation contexts are linked to the infrastructure PPP stages. The final section concludes the paper.

2. The meaning and antecedents of infrastructure PPPs

The PPP concept itself is commonly defined as 'co-operation of some sort of durability between public and private actors in which they jointly develop products and services and share risks, costs and resources which are connected with these products' (Van Ham and Koppenjan 2001, p. 598; see also Klijn and Teisman 2003). This definition embraces a wide range of cooperative institutional arrangements of a more or less binding character, ranging from relatively loose policy communities and issue networks to more binding, long-term contractual relationships with specific deliveries (Hodge and Greve 2005). Weihe (2008) distinguishes between four PPP literature families (infrastructure PPPs, urban-development PPPs, policy PPPs and development PPPs), each with distinct theoretical and empirical origins (see also Marsilio et al. 2011; Woodson 2016). Even within a relatively confined notion of PPP as a mode of infrastructure service delivery, which is our focus in this paper, a vast array of partnership types has been identified (Grimsey and Lewis 2004). What sets infrastructure PPPs apart from other types of partnerships is that the former are usually based on transactional relationships as opposed to collaborative relationships (Klijn and Teisman 2003). In infrastructure PPPs, 'the private partner may be tasked with the design, construction, financing, operation and management of a capital asset and service delivery to the government or the public using that asset' (Verhoest et al. 2013, xiii).

The conceptual roots and political motivations behind contemporary PPPs, including innovation, are diverse and include both micro-economic (collaboration, cost effectiveness, value-for-money, innovation), macro-economic (deficit, debt, private finance) and political rationales (privatization, public sector downsizing, private finance) (McQuaid and Scherrer 2010). Indeed, Hodge (2004) coined the discussion by noting that debates over what should be public and private have abounded for centuries and that 'PPPs are simply the latest chapter in the book' (ibid., p. 37). Especially at the organizational level, PPPs are commonly seen as a route to

improved collaboration in the public–private interface, thereby offering a means to realize collaborative advantage and innovation (Yescombe 2007). The very idea of innovation in PPP thus largely builds on the assumption that synergy and added value – something that could not have been achieved by the public and private sectors acting single-handedly – can be achieved via the PPP mechanism (Huxham 1993; Huxham and Vangen 2004).

The concepts of synergy and added value of collaboration have also been discussed intently in the collaborative public sector innovation literature (Bommert 2010; Sørensen and Torfing 2011). The synergistic aspects behind collaboration and innovation have been further elaborated and complemented in the PPP literature – predominantly on the project level – by exploring what drives innovation, how innovation is enabled or hindered by various factors, and how innovation contributes to lowering costs or enhancing quality with regard to specific public services (see more below) (Brogaard 2017). What the current literature is strikingly lacking, however, is the emphasis and understanding of how infrastructure PPPs contribute (or fail to contribute) to the emergence of new evolutionary paths in society beyond the projects themselves; that is, how innovations emerging through (or because of) infrastructure PPPs create new (or adjust the existing) evolutionary trajectories for the involved organizations in the public and private sectors.[2] And as already implied, these new trajectories should not be automatically regarded as positive, as innovations often have negative consequences.

In order to contribute to the elaboration of these issues, the next three sections conceptually examine the relationship between infrastructure PPPs and innovation from the perspectives of three different contexts: project, private sector and public sector. These insights are then combined and used as stepping stones towards a

[2] While one should obviously add citizens here as well, the current analysis only addresses organizations.

conceptual understanding of innovation throughout the key phases of the PPP value chain.

3. Innovation on the project level

Project-level innovation in PPPs has hitherto been the main focus of almost all the existing studies of the field, which is why we limit ourselves here to providing a brief summary of the prevailing arguments. The discussion is based on a review of the most authoritative studies of infrastructure innovation and PPPs. We collected the sources by searching for combinations of PPP and innovation in the Web of Science, supplementing the results with sources that were already familiar to the authors. In the Web of Science, we searched for studies combining ‘public–private partnership*’ OR ‘public private partnership*’) AND (innovat*) in the title, abstract and keywords. The searches included all articles written in English in the Social Science Citation Index published in all years. To further validate the list of sources, we checked the reference lists of all of the studies for additional relevant studies. These steps resulted in a list of 26 studies of innovation and infrastructure PPPs, which lays the foundation for the discussion below.

In the infrastructure PPP literature, project-level innovation is most commonly assumed to emerge from the possibility of bundling different infrastructure development stages together under competitive pressure and understood in terms of technical, design or processual innovations that lead to service-related productivity gains and quality or design improvement (e.g. Grimsey and Lewis 2004; Zhang and Chen 2013). Profit opportunities (Debande 2002), design freedom (Reeves 2003; Leiringer 2006), stimulating a collaborative environment for user–provider relationships (Eaton et al. 2006; Russell et al. 2006; Bougrain 2012; Chinyere 2013), risk transfer (Leiringer 2006), non-risk-averseness (Barlow and Köberle-Gaiser 2008; Demirag and Khadaroo 2010) and standards and performance specifications (Himmel

and Siemiatycki 2017) are thus considered to be key in inducing innovation in infrastructure PPPs.

Importantly, the evidence about PPPs contributing to the emergence of project-level innovation would appear to be much more scarce compared to the prevailing assumptions in the literature. There is some evidence that PPPs lead to incremental technological innovations (Debande 2002; Leiringer 2006; Chan 2009; Grasman et al. 2014; Himmel and Siemiatycki 2017), infrastructure-design innovations (De Lemos et al. 2003; Fitzgerald 2004; Leiringer 2006; Roberts and Siemiatycki 2015), and innovations in the organizational setup of infrastructure implementation and related maintenance and service delivery (Chan 2009; Codecasa and Ponzini 2011; Hoppe and Schmitz 2013; Willoughby 2013). In general, however, very little evidence seems to support the claim that innovation was a pervasive and inherent quality of infrastructure PPPs. Little is still known about which specific mechanisms enable, determine or inhibit innovation in PPPs and the negative consequences that may follow from innovation. Crucially, project-level innovations can be difficult to interpret, as they can benefit some stakeholders while leaving others worse off (Himmel and Siemiatycki 2017).

4. Innovation in the private sector

In addition to project-level impact, innovation can directly affect the existing routines and behaviours of companies involved in infrastructure PPPs; that is, infrastructure PPPs can be regarded as specific learning environments that enable (or disable) firms to acquire and institutionalize new knowledge, which in turn affects the behaviour of those organizations beyond specific PPP projects and which can become subject to imitation by other organizations. In some cases, PPPs have been shown to directly affect the organizational behaviour of the firms present in the infrastructure PPP

market, which may positively affect the firm's revenue; conversely, PPPs can also have negative social effects, such as market concentration (Roumboutsos et al. 2017).

Innovation is about '"doing things differently" in the realm of economic life' (Schumpeter 1939). New combinations of resources bring about five different types of innovation: new products or a new quality of a product, new methods of production, new markets, new sources of supply of raw materials and intermediate goods, and new methods of organizing economic process (see also Oslo Manual, OECD and EC 2005, pp. 46f).

In the Schumpeterian view, innovation is therefore something 'new' that has been applied in the marketplace: invention, knowledge production or new ideas are often part of innovation processes, but are not sufficient to qualify as innovation. The term 'new' is understood as introducing a combination in a specific context in which it has not been used before. Although this can come close to imitation, it is of a different nature in the sense that an adaptive effort is usually required which, in turn, resembles incremental innovation (Niosi 2012). Thus, innovation is a cumulative process wherein one innovation (e.g. driven by first-mover advantage) leads to imitation and further innovation by other firms (driven by profit opportunities) that eventually changes entire sectors, markets and society (Dosi et al. 1997; Fagerberg 2005).

However, innovation is not only a technological but also a social and organizational phenomenon. While this is due to organizational innovation in a narrow sense, it also relates to institutional innovation being required to complement technological innovation (Perez 1983; Van de Ven 1986). It is therefore not for technological reasons alone (e.g. feedback loops leading to incremental improvements) that innovation is essentially a continuous process rather than consisting of discrete phases (Fagerberg 2005).

In the private sector, market competition is the ultimate test of whether something new is considered an innovation (if the market accepts the new product, process etc.)

or not (if it fails to gain acceptance in the market). Just being ‘new’ is therefore insufficient to be considered innovative, and innovation does not necessarily mean ‘progress in society’, representing a Schumpeterian process of ‘creative destruction’, but also ‘“destructive creation” … innovation benefiting a few at the expense of many’ (Soete 2013, pp. 134ff). In other words, the market selection process is the primary determinant of the relevance of an innovation, together with if and how it influences economic and social change.

Infrastructure PPPs can be considered a special case of market selection processes. One of the key aspects here is the potential of PPP projects to form new linkages and relationships between various actors. The actors in the innovation process as well as the linkages and feedback loops between the actors are the key phenomena of national innovation systems that are shaped by (1) technological, industrial or sectorial characteristics of innovation actors or (2) spatial characteristics (Lundvall 1992/2010). More specifically, regarding infrastructure PPPs and innovation in the private sector in general, following dimensions can be outlined. First, PPPs offer a mode of fostering the generation and exploitation of innovation activities by providing the organizational frame for ‘producing’ innovations and bringing new products, processes, modes of organization etc. to the market, thereby affecting the evolution of the capabilities and skills of businesses (Kristensen et al. 2016).

Further, PPPs act as a variety-creation mechanism by linking agents from different sectors in the innovation process, thereby creating new opportunities for user–provider interactions and learning. Like public procurement, standard setting, regulation or support for private demand, infrastructure PPPs can be conceived as a potentially powerful demand-side tool to shape and guide innovation. Following the general thinking about demand in innovation processes (Mowery and Rosenberg 1979; Edler and Georghiou 2007; Nemet 2009), PPPs can potentially impact the general level of demand in an economy and stimulate learning and innovation in firms. By introducing sophisticated demand within the context of PPPs, the public

sector is positioned to incentivize service providers (i.e. private businesses) to come up with new solutions for supplying and organizing public services. In so doing, the public sector can spur the creation and diffusion of new skills within and beyond the public sector, which, in turn, feeds into the broader process of economic and social change.

In this way, PPPs contribute to the performance of innovation systems in general by strengthening the quality of feedback linkages in the economy. Here, the quality of demand or the ways government articulates user needs for private partners is a key factor affecting market behaviour. By demanding the development and application of new products and solutions, the public sector can act as a testing ground for innovative products, encouraging innovation by providing a 'lead market' for new or promising – but not yet widely applied – technologies (Rothwell 1994; Edler and Georghiou 2007). Innovation-oriented PPPs can also affect business capabilities by using functional requirements and other innovation-conducive procurement principles (Hommen and Rolfstam 2009; Lember et al. 2015), and government can combine various other innovation policy instruments (e.g., tax breaks for R&D investment, R&D grants, innovation-supporting regulation), deliberately linking this innovation policy mix to specific PPP projects. Thus, the use of functional requirements instead of input requirements may, for example, induce introduction of new materials in construction, new processes in toll collection or new organizational processes that can alter not only the involved businesses, but also later diffuse across markets.

Finally, PPPs are relevant for the build-up and operation of innovation-related infrastructure, which facilitates the development and diffusion of new technologies throughout society. Transport, health, education and other key infrastructures are vital prerequisites for innovation activities, as they facilitate the organization and diffusion of innovations (Kristensen et al. 2016).

Yet our literature review indicates that infrastructure PPP studies do not generally account for whether the possible efficiency gains and other outcomes stemming from

project-related innovations resulting from PPPs presumed that the private sector changes their capabilities and routines (cf. Roberts and Siemiatycki 2015). If efficiency and other gains mainly resulted from incorporating the existing market capabilities into the realm of public service delivery, PPPs might improve public service, but new evolutionary paths in the markets would not result. Importantly, the impact of innovations emerging from PPP projects may not necessarily be apparent in project outcomes (e.g., cost reduction, better design), but rather through the actions of the involved companies beyond the projects. As such, little is known if and how PPPs induce innovation in the respective markets. Moreover, much of the current literature does not delineate between changes in private and public organizations, nor does it pay much attention to the positive and negative feedback loops that might reinforce such change. There is also a lack of documentation of the claim that innovation is a result (an effect) of PPPs itself rather than the increased focus on innovation. While innovation can occur both as a result of the innovative acts of the parties involved or due to the sheer scale and complexity of PPPs (see Raisbeck 2008), the empirical literature remains almost silent on this important issue.

5. Innovation in the public sector context

Innovations emerging through PPP projects can potentially also lead to the creation and institutionalization of new technological and organizational capabilities in the public sector. Despite growing scholarly interest in public sector innovation as a concept and practice, considerable confusion remains concerning what innovation means in the public sector, how it can be conceptualized, and what the public sector can learn from the private sector innovation literature (see Drechsler 2009; Pollitt 2011; Lynn 2013; Fagerberg et al. 2013). There is an emerging consensus that innovation in the public sector should be viewed as a radical departure from old solutions (Osborne and Brown 2013) and that the new solutions have to be sufficiently radical to bring about irreversible changes in core tasks (or routines) in

public sector organizations (Lynn 1997). Related to the organizational perspective, different system-level innovations are crucial in the public sector context and can either facilitate or determine radical change in organizations and society: new kinds of regulation, public infrastructure, social relationships, governance mechanisms (including PPPs) and public policies more broadly (Windrum and Koch 2008; Osborne and Brown 2013; Valkama et al. 2013; Wynen et al. 2014).

The public sector innovation (PSI) literature focuses on three partially overlapping themes of innovation. First, innovation-related activities linked to changes in organizational performance (e.g. productivity, effectiveness) (Valkamaa et al. 2013; Dunleavy and Carrera 2013). This covers various efforts from the introduction of new services and processes to policy-, conceptual- and system-level innovations (Windrum 2008). Second, new services and means of service delivery that ultimately alter citizen–government relations (Hartley 2013). Here, compared to physical products, the focus is on interactivity as a core characteristic of services (Miles 2005) and democratic governance. And third, the focus is on public value creation in its widest sense, thus pointing out the need to consider qualitatively different values compared to market-relevant innovations (Moore 1995). These public sector innovation processes use different modalities (innovations within and through public sector), agencies (the public sector proactively initiates changes or reacts to technological, environmental etc. changes) and morphologies (from incremental to discontinuous changes) (Kattel et al. 2018).

Despite the calls to relate public sector innovation to specific public sector features, such as public values, transparency, accountability, and political and policy contexts (see e.g. Hartley 2013; Bernier et al. 2015), the underlying logic of analysing the innovation mechanisms in the PSI literature still borrows heavily from private sector thinking (Kattel et al. 2018). This poses a theoretical challenge, as it is unclear whether public sector and industrial innovations can ‘be studied through the same “lenses”’ (Fagerberg et al. 2013, p. 13). Among other aspects, the absence of profit

opportunities, replication and market selection mechanisms make it important to unpack the specific evolutionary mechanisms of innovation in the context of the public sector and understand how this differs from innovation in the private sector. Yet there is a limited understanding of which mechanisms determine the variety creation processes in the public sector, how the selection process works pertaining to innovation, and which results and capabilities are to be considered successful. As there is no natural selection mechanism similar to market competition that could determine the success (or lack thereof) of 'new combinations', the understanding and evaluation of innovation in the public sector context has remained disputed.

Bearing in mind the caveats regarding the concept of public sector innovation, we can outline the following innovation dimensions relevant for the public sector beyond specific PPP projects. First, introducing PPPs may significantly alter the organizational routines of public organizations. Direct innovation effects emerge if PPPs assume new capabilities and learning patterns are developed in order to launch and implement a project. Additionally, PPP projects may reinforce the newly acquired capabilities, potentially altering the core routines of the involved organization in the long run (Lynn 1997) and lead to, for example, introduction of PPP projects in unfavourable contexts. Indirect innovation effects may emerge as a side-effect of a PPP project if, for example, the productivity of a public sector organization increases or decreases due to the redesign of work teams and/or coordination processes within or between public organizations (Dunleavy and Carrera 2013).

Second, governments often play a key role in developing new solutions to emerging problems, such as demographic shifts or environmental challenges, but they may lack the legitimacy, knowledge or resources to address such concerns alone (Mowery et al 2010. These challenges often pose existential problems for societies, and the re-combination of existing or new resources may be inevitable to overcome them. PPPs are in fact actively pursued by many governments to tackle challenges like the

diffusion of clean energy in transport, the use of energy-efficient materials and products in construction or new health-care solutions in hospitals. Thus, PPPs may potentially act as a vehicle for new knowledge-creation and diffusion in tackling societal challenges. At the same time, radical new solutions usually require institutional, organizational and regulatory changes in addition to technological innovations (Perez 2002).

Third, PPPs can stimulate important change in governance and public-service provision when used as a tool to introduce market deregulation. While public monopolies in the transport, health and energy sectors have traditionally provided 'public goods', the introduction of PPPs has changed this by engaging private market operators and sometimes citizen groups in order to meet public needs. PPPs open up possibilities for the market and citizens to become involved in public policymaking, thereby making it possible – for better or worse – to alter the control and accountability arrangements in society. At the same time, governments can apply new governance mechanisms, such as PPPs, when developing the strategic capacity of various social and market agents (Jayasuriya 2005) in order to increase government legitimacy (see also Peters and Pierre 2010). PPPs therefore alter not only the relationship, accountability and authority structures between government and market, but also between government and citizens.

By concentrating mainly on public service delivery performance and efficiency (cf. Akintoye et al. 2003; Brewer et al. 2013; Javed et al. 2013), and – to a lesser extent – on broader public values, such as the environment (Grasman et al. 2014) and education (Robert and Siemiatycki 2015), the PPP literature largely ignores the systemic nature of innovation and its impact on public sector change. However, conceptually grasping innovation in the context of PPPs not only assumes that one understands the system that influences innovation (cumulativeness, inter-relatedness), but also how innovation influences the evolution of the wider institutional system that regulates and enables PPPs (Verhoest et al. 2015; Van den Hurk et al. 2016). As

noted by Bourn (2003), however, there is little evidence in the literature documenting that this interaction effect has any impact beyond a particular PPP project on the general organization of the public sector more broadly. In this sense, the current PPP and innovation literature has been limited in its conceptualization of what constitutes innovation in PPP, and existing empirical studies generally provide modest evidence on innovation outcomes that can be causally linked to the organization of infrastructure projects as PPPs.

6. Towards a conceptual framework for innovation in infrastructure PPPs

Until now, we have argued that innovation in the context of infrastructure PPPs has much broader connotations and potential effects than that which has been emphasized in the literature so far. Yet it is equally important to understand *how* exactly PPPs can stimulate project-related innovation and new evolutionary trajectories in the public and private sectors. For example, in order to fully grasp the significance of innovation in PPPs, we should not restrict ourselves to only studying project-related efficiency gains or design advancements, but also attempt to reveal the long-term (cumulative) impacts emerging from how these efficiency gains, design advancements and other potential positive (and negative) impacts were achieved. The following is an attempt at unpacking the innovation mechanisms based on the above-mentioned conceptual and empirical arguments and through the typical infrastructure PPP stages (see table 1 below). Crucially, at this point we only present the key building blocks in the relationships between different innovation contexts and PPP stages, leaving other crucial issues, such as the dynamics between the factors, for further research.

In addition to the stages of the infrastructure PPP value chain that usually receive mention (design, building, financing, maintenance/operations and transfer), we also explicitly address the procurement stage. This stage is particularly relevant because, first, the choice of PPP as a mode of infrastructure delivery may constitute an

innovation as such when PPP or a new variety of it is used for the first time within a sector, country or region. Second, and more importantly, in the procurement stage, the scope for possible innovation in the value chain of a PPP project is largely determined by the design of the PPP contract (which marks the end of the procurement stage) (see Lember et al. 2014 for a theoretical overview). The tendencies towards professionalization in the PPP industry and standardization of PPP contracts (van den Hurk and Verhoest 2016) may allow 'governments buying off-the-shelf standardized solutions' (Hodge and Greve 2018, p. 9). While contract standardization reduces transaction costs, thereby facilitating infrastructure procurement through PPPs, it also reduces the flexibility of PPP delivery which, in turn, could weaken the incentives and reduce the possibilities for innovation in other stages in the value chain. Third, the (typically) risk-averse behaviour of private financers tends to prefer PPP contracts with low financial risk exposure, which impedes the scope for technical or organizational innovation. Nevertheless, within the boundaries of the PPP contract, the potential for innovation remains in all stages of the PPP value chain (see table 1).

Innovation may have rather varying relevance in different contexts (project, markets, public sector), and the dominance of innovation dimensions in PPPs also varies along the value chain. PPPs always involve multiple stakeholders operating under very different institutional rationales (Klijn and Teisman 2003). Moreover, it is not just the different logics of the private and public sectors, but a mix of sector-specific (finance, construction, services) and policy (fiscal and field domains, such as transport or construction) rationales that shape and characterize PPPs. Moreover, partnership projects are designed in the political arena (Flinders 2005), which adds yet another layer to the PPP-specific innovation process. Innovation in PPPs can thus have very different meanings and consequences for various PPP stakeholders, such as government, private market agents or society in general, and these differences can lead to conflicts. In turn, conflicts and how they are resolved become important

sources of innovation (Coriat and Weinstein 2002). While other studies have predominantly focused on the project level, we concentrate on the involved public and private sector organizations. From a market-centred perspective (see table 1), PPP is a mode of fostering the generation and exploitation of innovation by acting as a variety-creation and -selection mechanism, which is important in all forms (new product, process, material, market, organizational design), although not in each stage of the PPP value chain. Even if not reflected in project-related outcomes (e.g., efficiency gains, design improvements), the competitive pressure or the use of performance specifications and sophisticated standards can induce private partners to upgrade their product or process capabilities, which can play an instrumental role in their other activities beyond the project.

Table 1: Main aspects of innovation in PPPs along the PPP-value chain

Main aspects of innovation in PPPs	*Stages in the PPP value chain**					
	Procurement	*Design*	*Finance*	*Building*	*Operations/ maintenance*	*Transfer*
Economic domain(s) in which innovation potentially takes place	Public procurement processes	Design of all aspects of providing a public service	Financial sector	Construction and its supply industries	Service provision	Public property accumulation; (re-) transfer of assets to public sector
Examples of activities potentially triggering innovation	Multi-stage tendering in infrastructure procurement	Designing infrastructure to minimize lifecycle cost	New sources of infrastructure finance; new financial instruments	Attempts at minimizing lifecycle cost leading to technical innovation (e.g. in construction, equipment)	New forms of user charge collection (technical and organizational innovation) leading to changes in user behaviour and government monitoring practices	Asset transfer from SPV** to public sector after contract termination
Most important stakeholders and industries	Procuring public sector agent; bidding consortia	Procuring public-sector agent; SPV; architects/engineering consultants	Financiers; SPV	Construction engineering consultants; SPV	SPV; users	Procuring public-sector agent; SPV
Dominant innovation dimension in private sector	Variety creation and selection (new organizational design, new process)	Providing innovation-related infrastructure; variety creation and selection	Variety creation and selection (new organizational design, new process, new market)	Variety creation and selection (new product, new process, new material, new organizational design, new market)	Variety creation and selection (new product, new service-provision process)	Maintaining innovation-relevant infrastructure
Dominant innovation dimension in public sector	Change in public sector routines; strategic change in governance	Change in public sector routines	Strategic change in governance	Change in public sector routines	Strategic change in governance	Strategic change in governance
Selected lessons from the literature	Project specifications are crucial for the scope of innovation	Impact of design-specifications on the scope for innovation is unclear	Typically risk-averse financiers impede technical innovation	SPV has an incentive to innovate, e.g. to reduce lifecycle cost	SPV has an incentive to innovate; users may benefit from and push for innovation	No clear lessons yet

* Depending on the extent of pre-design of the service to be procured by the public authority, the sequence between the *procurement* and *design* phases might be reversed. Depending on the chosen model of PPP, a project need not comprise all stages.
** SPV – Special Purpose Vehicle.
Source: The authors

From a public sector-centred perspective, the dominant innovation dimensions also vary across stages (see table 1). While a PPP may primarily be a catalyst of change in the public sector organizational routines in the earlier stages, it can bring about strategic change in governance in most stages of a project. The former aspect plays a key role in organizations responsible for PPP commissioning, as they may need to acquire new knowledge and routines to use and formulate performance specifications, standards and other mechanisms to act as a 'smart buyer', a capability they can then use in other situations beyond PPP projects. The latter aspect depends on a mix of factors specific to the public sector, such as authority, control and legitimacy (Kattel et al. 2018), which explain if and how government is ready and able to empower citizens in the PPP process or counterbalance the interests of private-sector stakeholders, thereby changing the relationships between the public sector and its external stakeholders. Again, capabilities acquired during these processes can significantly affect how government approaches similar relationships outside the specific PPP project.

More specific examples of activities potentially leading to innovation (see table 1) include designing and building infrastructure with regard to minimizing costs over the whole lifecycle, tapping new sources of financing for infrastructure, implementing new forms of user-charge collection and multi-stage tendering, which has since long been identified as an enabler for innovation in public tendering (European Commission 2007; Rolfstam and Ågren 2014). Similarly, PPPs have been used as a pull mechanism for innovation aimed at improving environmental standards (Grasman et al. 2014). Importantly, these activities can also catalyse innovation in all of the contexts examined in this article – project, private sector and public sector.

Each stage of the value chain is dominated by very few (groups of) stakeholders (see table 1): the procuring public-sector agent, the bidding consortia, the financiers, the 'special purpose vehicle' (SPV; i.e. an organization consisting of contractors related to the project which is established to implement the PPP contract), engineering and construction firms, and the users of the infrastructure provided by the PPP. As stakeholders are characterized by different technological competences, technological and interaction patterns (Pavitt 1984; Castellacci 2008) and sectoral innovation systems (Malerba 2004), innovation behaviour and the potential innovation outcomes in various PPP stages differ.

A major potential of PPPs for enabling innovation stems from intensifying inter-sectoral linkages and knowledge flows between firms with different technological competences and strategies, which may release external economies and reinforce change in organizational

routines beyond the individual PPP project. While special suppliers, engineering and ICT service providers are among the most dynamic and knowledge-intensive sectors under the current ICT-led techno-economic paradigm (Castellacci 2008), they typically have not been key players in PPPs. Demand for innovation in these industries is determined by typical PPP players, like construction companies and infrastructure service providers, which use intermediate goods from knowledge-intensive industries as an input to their innovation activities. Here, the public sector can act as a major facilitator by articulating needs and designing PPP set-ups that can 'pull' innovation and facilitate the knowledge flow between stakeholders. To achieve this, the public sector may need to reorganize its own institutions and organizational structures, leading to the upgrade of administrative capabilities within the public sector. The need to cope with the new technologies emerging from PPP may also trigger such changes.

Because of the prominent role of finance for providing infrastructure and risk-sharing between public and private agents as an inherent characteristic of PPP, financial motives play a role when economic policymakers are deciding on PPPs as a mode of infrastructure provision (McQuaid and Scherrer 2010). While the provision of public infrastructure through PPPs unto itself once represented financial innovation, PPPs now trigger various types of innovation in the financial sphere. Syndication and the securitization of loans for PPPs were introduced by private agents in the 1990s, and governments have tried to increase the lending volume for infrastructure PPPs since the global financial crisis using a variety of interventions, including the direct public provision of capital and state guarantees for scheduled debt payments and for refinancing PPP infrastructure debt (Hellowell et al. 2015). Again, these new solutions can potentially influence not only future relationships between government and the private sector, but also how the finance sector carries out its other businesses.

Applying the market-centred and public sector-centred approaches to current empirical findings provides some preliminary lessons. Growingly risk-averse financiers might act as an impediment to technological innovation, but probably not to financial innovation, as they assume to be better able to judge the risks involved in financial transactions. As an important player in the financing, building and operating stages, the SPV has an incentive to innovate (e.g. lowering the lifecycle cost), but because it acts within the boundaries of the PPP contract, its scope to go for more than mere incremental innovation (particularly in the building stage) already seems to be largely determined in the procurement and design stages.

Thus, the design specifications are crucial for the scope for innovation within a PPP. In the operating stage, the users of infrastructure may push for and benefit from innovation.

To summarize, each stage in the PPP value chain can potentially trigger innovations in public service delivery as well as new evolutionary trajectories both from a market-centred and a public sector-centred perspective. The direction, nature and impact of these potential new evolutionary trajectories differ depending on the sector concerned. Each PPP stage can be both an enabler as well as a constraint on innovation, and new evolutionary trajectories triggered by PPPs should not automatically be considered positive. For example, while PPPs can function as a testing and diffusion platform for new products that can contribute to upgrading private sector capabilities and thus economic development, PPPs can also disproportionately increase the control of private businesses over citizens and governments in coordinating and deciding matters related to public life. Similarly, a PPP applying radically new design and service delivery solutions may trigger a myriad of cumulative changes in other organizations which may lock them into chosen development paths for decades, even if superior 'ways of doing business' emerge.

7. Conclusion

This conceptual paper has addressed two major shortcomings in the current infrastructure PPP and innovation literature. First, as shown in our review of previous PPP literature, the existing take on innovation in mainstream PPP scholarship is somewhat limited. While the term 'innovation' is frequently used when describing the characteristics of PPPs, previous literature rarely systematically explores the innovation aspects beyond the context of individual PPP projects.

Second, in order to remedy the shortcomings, we conceptualize innovation and PPP in three contexts: PPP projects, private sector and public sector. While providing only a brief overview on the main innovation logics in the context of PPP projects, we argue that the market-centred approach prevailing in the private sector can be built on the Schumpeterian view of innovation as an evolutionary process on the market, where PPP may incentivize evolutionary change among market players either directly via new solutions or indirectly by providing innovation-relevant infrastructure. In contrast, the public-sector approach tends to perceive PPP as a means of catalysing change in public organizational routines and strategic changes in governance, thereby meeting societal challenges and increasing or decreasing political legitimacy. The importance of these dimensions varies along the PPP value chain in

the private and public sectors alike. Central to these dimensions is that they provide us with a starting point to understand the innovation potential, triggering mechanisms as well as the impacts of the long-term evolutionary change that PPPs can initiate. The direction and rate of the potential of the new evolutionary trajectories emerging from PPPs can vary depending on the sector and policy domains concerned. Importantly, PPPs in itself or innovations stemming from PPPs should never automatically be assumed to be positive as these new trajectories can have both negative and positive consequences.

In order to bring more clarity to the conceptual definition of innovation in PPPs, the innovation potential needs to be determined by the interplay between different stakeholders. While the article has outlined this approach, the topic requires further investigation and consideration, as do all aspects of innovation in PPPs. Moreover, we still have only limited empirical evidence on how the PPP stages constrain or enable innovation, and what kind of long-term consequences emerge from PPPs in terms of societal change more broadly. This suggests that innovation in PPPs requires a more nuanced and longitudinal view than is currently acknowledged in the literature, and only then will it be possible to establish less ambiguous concepts for innovation in PPPs. Such work also has the potential for furthering the understanding of the institutional and other conditions that support and inhibit innovation in the interplay between the public and private sectors.

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