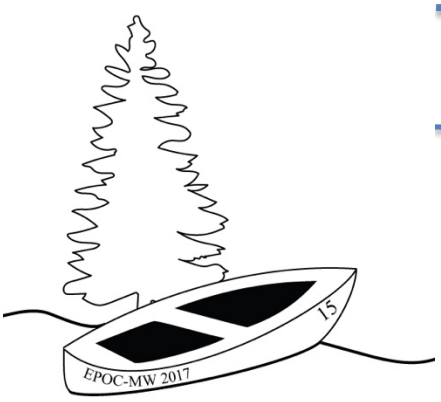

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Technology, Business, or Resource? Towards an Architecture of Value Creation in Infrastructure Projects

Vedran Zerjav, University College London, United Kingdom

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TECHNOLOGY, BUSINESS, OR RESOURCE? TOWARDS AN ARCHITECTURE OF VALUE CREATION IN INFRASTRUCTURE PROJECTS

Vedran Zerjav[1]

ABSTRACT

The aim of the paper is to develop a conceptual framework for understanding infrastructure as a domain of cross-disciplinary inquiry in general and infrastructure projects as a unit of analysis in particular. By drawing upon a diverse body of work in technology and design studies, business studies and neo-institutional economics, the paper derives a set of working propositions pointing towards infrastructure projects as vehicles to develop mature technologies, business systems, and shared resources as the three important functions that infrastructure performs for the society. Integrating this theoretical framework with the extant studies on projects as temporary organisations and systems lifecycle value creation, the paper then derives a propositional typology of resulting value destruction patterns. These patterns can be seen as hypothetical situations, in which projects fail to generate and deliver value to their users - thus incapacitating the value capture processes further down the road. The utility of the propositional typology developed is that it allows for a greater conceptual clarity in understanding the value mechanics for infrastructure projects. Finally, the paper argues that the phenomena of value and their dynamics in infrastructure projects is a promising area for future inquiry.

KEYWORDS: Infrastructure policy, Governance and finance, Project organising, Value creation, Innovation studies, Management of Projects.

INTRODUCTION

Infrastructure is occupying an increasingly prominent place in the public discourse. Political leaders both in the developed and developing world promise to build (or rebuild) the infrastructure to serve the public interest, businesses are getting into the area and the institutional investors are casting their eye on future projects that they could use as safe investment havens for their clients. There is broad consensus about infrastructure being an important asset to the society both nationally and globally and it certainly looks like this will remain to be the case for the foreseeable future. All this leads to a number of research programmes that address infrastructure issues in different forms, but 'infrastructure studies' as a domain do not exist.

Despite a broad consensus about the importance of infrastructure there is a surprising lack of coherence in what is really being addressed in the existing discussions on the subject matter. Urban planning, organisation studies, economics, engineering and policy studies all deal with different units of analysis, which as established academic disciplines they do with great rigour. However when the

[1] Lecturer, Bartlett School of Construction and Project Management, University College London, v.zerjav@ucl.ac.uk

argument linking the disciplinary unit of analysis with the much more broader picture of 'infrastructure' is being made, according to the present author's experience, this is done vaguely, and - what is more - consistently so across various academic, policy, and industry disciplines.

Although there could be some short-term advantages of this approach[2], it is also clear that the lack of convergence around an identified domain of analysis can lead to at least two problems. First without a coherent conceptual focus, policy makers' focus on infrastructure will shift to other areas, ostensibly with higher societal relevance. As research funders' strategic priorities will follow along, the field of 'infrastructure inquiry' is at great risk of being perceived as a 'flavour of the day', similarly to some other policy and industry 'hypes' that have ultimately generated much less traction than envisioned (Green 2011, Dainty et al. 2015). The other risk in this vagueness of definition is that in policy making language, 'infrastructure' is used to denote 'all that is important for the functioning of the society', which in author's opinion, is equally unhelpful because it leaves the subject matter at the level of public discourse with few opportunities to apply analytical tools and critical reasoning. Neither the shift of policy focus nor the all-encompassing understanding of infrastructure would in itself be a problem as the goal of research funders is to support research, which is of highest impact for the society (Nightingale and Scott 2007), but the argument in this paper is that the very nature of infrastructure, when (and if) defined as an interdisciplinary analytical domain, will be a strong argument for it to pass the societal relevance test and continue to be an important research area that contributes to opportunities for societies around the world.

The paper develops the argument that, rather than focusing on time and cost overruns and benefits shortfall of projects, the 'elephant in the room' is in the domain of value that the delivery of infrastructure creates for their users through service provision over long periods of time[3]. As a result, in order to make better informed decisions about infrastructure investments and execution, we need to understand how are infrastructure projects creating value for the society and businesses and how is the project, as a result of its value, able to pay for itself over the long run. In other words we need to explore the value mechanics that will allow for sound investment, design, execution and operation decisions.

Value creation and capture is traditionally dealt with in mainstream business innovation research (Dodgson et al. 2013). However, with a few exceptions (Gil et al. 2012, Dodgson et al. 2015, Whyte et al. 2016), there is very little empirical research on how, besides the traditional revenue-based and firm-centric commercial models of value, infrastructure projects address a much broader agenda including social and environmental goals, long-term service provision, and synergies with existing

[2] Chiefly related to promoting innovation by encouraging a diversity of approaches to an 'ill defined' problem.

[3] To explain the rationale, I will use the analogy of undergoing a surgical procedure as a project. The decision whether to undergo a procedure is only partly determined by the complexity, costs, or the notional amount of pain and suffering the patient has to undergo during the surgery and the post-operative period. The real decision is, on the contrary, most likely going to be focused on the health benefits that the patient will have obtained a result of this (painful) experience. Of course, both the surgery and the recovery period can end up being much more complex, lengthy and costly than what the patient has initially given consent to undertake, but the framing of the decision-making is sill not focused on the 'accuracy of cost estimates' but the 'promise of benefits'.

projects and networks of assets. It is these alternative forms of value that are essential to the successful delivery of infrastructure projects.

For the purposes of this study, the creation of value will be defined as everything that needs to happen in order for the service to be delivered to the users and operators (stakeholder consensus, planning and design decisions, sound performance of the delivery alliance and migration into operations and use). The value creation processes encompass a wide value chain including governments, infrastructure clients (or possibly owner/operators), the delivery alliance, operators and users. Value capture, on the other hand, can be understood as the setup of actors and activities that need to take place in order for infrastructure to sustain itself financially over the long term. The value capture mechanisms for infrastructure should compensate for the capital expenditure for the asset as well as its maintenance and operation costs.

To advance the understanding about the value of infrastructure projects, the paper draws upon a diverse body of research to define the various 'jobs' that infrastructure performs for the society. The argument then turns to the important role of project organising for the provision of infrastructure assets in an attempt to define the infrastructure project as a unit of analysis. By discussing the technological, business, and resource views of infrastructure as an asset class, the paper derives some most obvious issues and pathologies, which represent instances when the dominant rationale breaks down. Finally, the paper develops a preliminary typology for value mechanics that integrates the different theoretical angles with the systems-lifecycle view of projects (Edkins et al. 2013, Morris 2013, Artto et al. 2016). The aim of this effort is to establish common ground that will allow for future theoretical and empirical infrastructure studies in the engineering project organisation domain and beyond.

INFRASTRUCTURE, PROJECTS, AND VALUE

Infrastructure provides businesses and consumers with essential public goods and services (OECD 2007). For purposes of this article we will define infrastructure as a class of technologies that provides essential services to the society (ICIF 2017). Such technologies support a wide range of sectors: from transportation, water & waste, energy and ICT to healthcare, education, justice, and housing and regeneration (IPA 2016). As the provision of these essential services is complex and prone to market failures, infrastructure requires government regulation and cannot operate in notional open markets. Moreover, the industrial structure of infrastructure provision is a combination of project- and operations-based modes of organising (ICIF 2017). The purpose of discrete project investments is the generation of assets, which feed into the provision of the essential services. The historical genesis of this two-fold industrial structure is such that a lot of what we now consider as the basic tenets of urban living are systems are services, which have evolved over long periods of time from luxury goods into commodities solidifying into what is now perceive as the basic fabric of everyday activity. From end users' perspective, the 'taken-for-grantedness' becomes the main property of infrastructure taking the discussion away from the production-based industry economic discourses into the realm of institutional theorising (Scott 2013).

It is namely that through the provision and maintenance of infrastructure, that governments around the world are looking to achieve better social outcomes for their communities, higher productivity of industries and individual businesses, all of which

is widely considered to improve the overall quality of life of citizens. This demand and interest is reflected in the proportion of infrastructure investment, which has reached unprecedented levels both in the industrialised and developing world (McKinsey Global Institute 2013). Nonetheless, most of infrastructure is delivered to their users and operators in the form of projects, which - through time - have demonstrated a remarkably consistent pattern of being delivered over budget, over time and not performing as expected and promised (Flyvbjerg 2014). Research on the success (or lack thereof) of infrastructure projects (often also understood as mega-projects) has pervaded both academic and practitioner-oriented literature. This literature often refers to the 'productivity paradox' (Flyvbjerg 2009) in these projects, whereby the delivery of infrastructure projects has not yielded improvements in performance that can be observed in similar conditions across other industry sectors. That is, in spite of a remarkable amount of knowledge that must have accumulated due to the extensive experience in planning, design, construction, and delivery of infrastructure projects[4]. Arguably, this is a consequence of three problems - we decide to build the worst projects, we are unable to make planning and execution decisions effectively, and - even when we manage to achieve the decisions - we executing the projects ineffectively.

In order to understand how value is generated and accrued over the period of infrastructure project planning, execution, and operation, I draw upon the principles of design research, which enables the development of solutions and course of action that will achieve desired outcomes. Rooted in American pragmatist philosophical tradition as opposed to traditional Popperian principles of scientific rationality, design theorising is focused on practical relevance and problem-solving rather that formal rigour of positivist (or otherwise) interpretations of reality. Recently, design science has acquired an increasing level of prominence not only in applied sector research, but also in mainstream operations management research (van Aken et al. 2016). By drawing upon a diverse body of literature such as technology and design (e.g., Simon 1969/1996, Dorst 2011, Nightingale 2014), organisation and business studies (Davies 2004, Brady et al. 2005, Davies et al. 2006, Teece 2010, Baden-Fuller and Haefliger 2013), and neo-institutional economics (e.g., Williamson 1985, Frischmann 2012, Scott 2013), the following section attempts to create a multilevel conceptual framework to understand the role of infrastructure and infrastructure projects as a vehicle for its realisation.

1. INFRASTRUCTURE PROJECTS DELIVER MATURE TECHNOLOGIES

The first view to be proposed is one drawing upon the view on infrastructures as mature technologies. In this view, infrastructure refers to artificial entities which are a result of a goal-orientated problem-solving process. Very much in line with design research (eg., Simon 1969/1996, Schön 1984, Dorst 2011), this view assumes that infrastructures create value by providing solutions for large-scale (societal or economic) problems. Infrastructure as a class of entities, which are generated in a problem-solving process with an intent to fulfil a certain imposed function is very

[4] It would clearly defy common sense to say that the existing track record of infrastructure delivery did not yield substantial knowledge on how projects are embedded into the fabric of everyday urban life. Nonetheless, it would also be an overstatement to suggest that this knowledge is being captured and implemented on future infrastructure projects in any structured way.

much in line with traditional technology and engineering paradigms, very well epitomised by civil engineering as a domain of activity that changes not only individuals and societies but also natural environments. What distinguishes infrastructure as a class of technologies from, for instance pure science, is that technologies change the world to fit an idea, whereas in science ideas are developed until they match the world (Nightingale 2014). This reasoning is inherent to any kind of engineering being traditionally concerned with changing the world through a set of problem solving processes. The view of technologies being the result of creative and analytical processes of cognition and action-taking [5] has several important implications for infrastructure as a class of technologies.

Firstly, the main purpose of infrastructure becomes the solving of large-scale societal and economic problems. Second, drawing upon ideas from Nightingale (2014), infrastructures are much more than only a physical manifestation of a problem solving process. They comprise a wider setting of the institutional regimes and social structure which makes the performing of the artificial functions possible. Such settings are developed historically and have their built in path dependency mechanisms which, up to a certain degree makes the decisions irreversible and future oriented. This partially explains the fact that the infrastructures can be seen along the technology maturity timescale evolving from luxury goods and innovations which disrupt markets into commodities and taken-for-granted structures which no one seriously considers abandoning. One example of this is the emergence of the railway systems in the 18th and 19th century. Another one is the use of the internet and yet another is mobile networking and telephony (eg., Frischmann 2012). Other kinds of traditional infrastructures are technologies which are historically so deeply rooted that this reasoning becomes difficult to exercise (for example urban planning and road networks, water distribution systems and sewers going back to ancient history in Europe but other parts of the 'old world').

In such a way technologies are a product of the design processes in which abductive reasoning becomes the norm, as opposed to inductive and deductive thinking which are the dominant logic in the scientific and analytical processes[6]. Whereas the linear logical pattern of thinking is based on observing the reality (as in the popular anecdote on Newton's understanding the basics of classical mechanics by having an apple fall onto his head), and then either moving inductively or deductively to determine the cause of this effect, the thinking patterns in technology (design) have the opposite direction (Cross 2006, Pahl and Beitz 2013, Nightingale 2014). That is we are creating a new entity by working back and forth from what the final outcome will be to generate the solution to the problem (Dorst 2011). This means that traditional scientific thought processes are not helpful for design, technology development, and infrastructure as an example of the above.

Creating technology is therefore an iterative and creative process that moves back and forth between problem and solution in design cycles until the best fit is found.

[5] Traditionally, the decisions would be analysed separately from actions, but more recent design-focused organisation studies use the terms interchangeably recognising the entangled nature of thought processes and action.

[6] Abductive reasoning is often attributed to the philosophical school of thought sometimes referred to as american pragmatism, in particular John Dewey and William James who emphasised that knowledge on how we understand and learn is as important (if not more so) than the formal logic of induction and deduction used to determine whether something is true or false.

This is of course the case for infrastructure, but the difference between technologies created through manufacturing or other engineering processes is that opportunities of moving between the experiment and the idea are limited due to the costs and one-off nature of the construction processes. We cannot afford to have prototypes of infrastructure and the modelling needs to take place elsewhere - on computers, paper sketches and in people's heads (Jin and Levitt 1996, Ewenstein and Whyte 2009). The problem we have in projects is that they are often in unique social, political, and technical contexts that only allow for a muddling through approach rather than a more optimised process that has more guidance as in more consolidated operational settings.

The view of infrastructure as a set of mature technologies brings us to the first value destruction issue of infrastructure projects. To this end, we will look at situations in which the technology does not fulfil the imposed function - i.e. to provide a solution for a defined and understood problem. According to recent research on infrastructure projects, this happens in at least two settings. First, value creation can be compromised in the front-end of infrastructure projects where perverse incentives give rise to the phenomenon of 'survival of the unfittest' (Flyvbjerg et al. 2009). This is a condition where projects that 'look best on paper' get sanctioned, which incidentally are the same projects with the largest cost underestimates and benefit overestimates. The second situation in which value is not created by fulfilling the imposed function can be explained through polycentric governance issues whereby the complexity and lack of hierarchical structure of the organisation gives rise to the internal conflicting interests amongst the stakeholders which stifles consensus and the decision to take action (Gil and Baldwin 2014).

The second value destruction issue of infrastructure viewed a class of technologies can be attributed to the fact that they are shaped by the social, historical, political, and knowledge conditions but embodied into artefacts or 'things' (Latour 2005, Harty 2008, Henisz et al. 2012, Scott 2013). In these conditions, there is a danger of misrepresenting the 'thing' for what it embodies. This can lead to the technology development process being a goal in itself, but without taking into account the necessary institutional alignment and the creation of the ecosystem that will allow the technology to thrive (Nightingale 2004)[7]. Examples in the domain of mainstream infrastructure is when so called white elephant assets are created - with very use to anyone but expensive to maintain. One avenue for mitigating this particular misalignment pathology is through the lens of value capture and the role infrastructure as a class of business systems. This is the purpose of the next section of the paper.

2. INFRASTRUCTURE PROJECTS DELIVER BUSINESS SYSTEMS

The second view to be elaborated draws upon the notion that infrastructures not only fulfil a particular role in the society - to provide solutions for large-scale problems, but that they should abide to economic principles as business systems. Mainstream business literature refers to the v*alue capture capabilities* of firms in the value chain of providing products and services. The rationale for this claim is that

[7] We have seen how this reasoning has failed in the dot-com bust as exorbitant amounts of money were being invested into 'technology businesses' that did not have a value proposition beyond vague product-centric ideas and a vision (or indeed delusion) of a 'great product' which will not only find its application but disrupt mainstream markets. More often than not, however, such businesses failed because of the inability to deliver value to their customers.

businesses can be seen primarily as instruments for value capture and that unless a firm enjoys some privileged position of monopoly, value has to be created otherwise market mechanisms of competition will make sure that such businesses cease to exist (Porter 2001, Verdin and Tackx 2015). Adam Smith was right insofar as the invisible hand of the market indeed acts as the best regulator of value capture when consumption revolves around an output that is easily replicable and relatively simple (Frischmann 2004). The 'too big to fail' argument starts to have relevance as the complexity of services and interdependencies with vital parts of the economy becomes stronger. In these situations, firms will be able to capture more value than what they generate (Verdin and Tackx 2015). Value capture can therefore be understood as the basic survival instinct for any firm.

The phenomena of value creation and capture are often discussed in the mainstream management literature under the concept of business models (e.g., Baden-Fuller and Morgan 2010, Teece 2010, Baden-Fuller and Haefliger 2013). Business models have traditionally been used in a firm-centric context to describe ways in which companies create and capture value. Along these lines for example Bowman and Ambrosini (2000) suggested that value is a dynamic phenomenon that plays out in various exchange processes between firms. Firms create use value and are able to realise the value in its exchange form by engaging in bargaining processes with another firm or individual that perceives utility value for its transformation processes. More recently, there has been a burgeoning literature on business models (Markides and Sosa 2013, DaSilva and Trkman 2014, Saebi et al. 2016) mainly focusing on operationalising the concept of business models and where this research stream could go in the future. Business models research stream identifies the various vague definitions that have been used in various industries of what a business model is (Achtenhagen et al. 2013). Arguably the concept comes from the dot-com era when the term was often used to justify often less than sensible managerial decisions (DaSilva and Trkman 2014) with the term being interchangeably used to denote ideas associated with strategic management, dynamic capabilities, logistics and so on. A recent review paper (Wirtz et al. 2016) derives the following main themes of business model research are innovation, change & evolution, performance & controlling and design. The same study develops an integrated model, in which "the strategic components are divided into the strategy model, the resource model and the network model. Customer and market components can in turn be differentiated into the partial-models customer model, market model and revenue model. Finally, the manufacturing model, the procurement model and the financial model are subsumed among the value creation components." In such a way value creation and capture mechanisms are part of an interplay between these various building blocks, creating a phenomenon that can theoretically be captured only through multiple analytical levels (Lepak et al. 2007).

A recent study tried to operationalise the business model concept by distinguishing between value creation and capture as two dimensions along a continuum in which companies can make strategic decisions (Verdin and Tackx 2015). This work also suggests measurement devices for value creation and capture from a corporate perspective. While, the ratio of profit/assets is considered as a proxy for value capture, the ratio between brand value and revenues is seen as a proxy for value creation (Verdin and Tackx 2015). Along these lines, value creation is

understood as perceived by the users and that value capture is understood as a set of mechanisms in which suppliers of the product or service can obtain revenues and maintain profitability. One of the distinctions between the project-based business and long-term manufacturing endeavours is the disconnect between the temporary project organising and the long term continuous flow operations which is often reflected in the interests of the different actors in the supply chain. This gives rise to the value extraction behaviours due to the governance and organisational structures in infrastructure. Value extraction has been recognised by management scholarship as "the capturing of value from other stakeholders, either outside or inside the corporation, by manipulating the competitive market process to the company's advantage." (Strebel and Cantale 2014).

The construction industry has long been accused of the adversarial behaviours, arguably due to its fragmented nature and the one-off transactional mindset of doing business. In this setting, the practice has been one of successive layers of subcontracting and passing risks down the supply chain until the party who is effectively taking on the risk is least able to manage it. The practice of lowest bid contracting and then using the principal-agent hold-up situation between the client and contractor to extract value from the delivery phase by escalation of change claims has been the unfortunate norm and practice in a lot of the traditional construction processes (Ive and Chang 2007). This has led to projects been delivered with poor quality and unable to fulfil their expectations and generally a perception of poor productivity in the construction sector, which in the UK lead to the 'construction improvement agenda' as a top-down government initiative (Green 2011)[8]. Although there has been some uptake of the advice from the government construction improvement agenda - in particular relating to relational contracting, partnering, and implementation of building information modelling - it is also fair to say that the structural problems of the industry have by and large persisted and that the promised step change in how the industry delivers to the society and businesses has yet to happen. The main reason for this is that the construction project is a major carrier of risk for infrastructure provision so the execution risk is generally with the construction supply chain - exhibits patterns of value extraction behaviours.

Overall there is very little understanding of how firms can find healthy ways of capturing value in a project based business setting. Only one study could be found that expands the existing ideas of value capture to the space akin to infrastructure provision. This was conducted by Kivleniece and Quelin (2012) who looked at value creation and capture processes in the context of boundary choice in public-private arrangements. Such arrangements are a relatively recent attempt to integrate capital

[8] The longevity of the construction industry improvement agenda can - at least in the UK - be traced back to the stream of government reports that all seek to identify reasons and prescribe approaches for the improvement of the construction industry. Some of the more influential and widely cited of these reports have been focusing on the role of the client (Latham 1994) and the ways in which the industry can move away from its adversarial contractual nature into long term relationships based on measurements of sustained efficiency improvements (Egan 1998). More recently, the focus of the improvement agenda has broadened to include people, technologies, sustainability, growth, and leadership (BIS 2013). Green (2011), has historically traced the roots of the adversarial behaviours in construction in the late 1970s and the following large-scale (and by and large uncritical) uptake of managerialist concepts such as lean management and business process engineering.

expenditures and revenue streams over the project lifecycle[9], but they are often criticised and fraught with challenges for issues that will be raised in the next section.

3. INFRASTRUCTURE PROJECTS DELIVER SHARED RESOURCES

The third view to be discussed is a 'resource-based' view of infrastructure. This view hinges upon theoretical insights from law, economics and sociology to argue that infrastructure can be understood as a specific class of resources which serves the macroeconomic growth and development of societies (Frischmann 2012). More specifically, it has been argued that infrastructure reduces transaction costs in markets (Henisz et al. 2012) and that investing in infrastructure as a class of assets has a long-term promise (Monk et al. 2017).

Drawing upon the theory of the 'commons' (e.g., Ostrom 2015) infrastructure can be considered as an asset that serves a shared purpose, which brings the issue of access rights into the centre of the debate. There has been a slow but continuous shift in governance models for infrastructure provision around the world, driven by the argument that markets are able to generate efficiencies when compared to the hierarchical state governance systems. These market-driven efficiencies are, in turn, sought by introducing the institution of private ownership into the realm of infrastructure services provision. The 'public vs private' dilemma around infrastructure governance gave birth to the rich body of theoretical work that seeks to understand the macroeconomic role of infrastructure in societies and link this role with the most appropriate governance frameworks to deliver this purpose (e.g., Henisz et al. 2012, Gil and Baldwin 2014).

The consensus amongst scholars advocating for the 'commons' governance of infrastructure is that traditional infrastructures have been openly accessible - meaning that anyone and everyone is allowed to access the resource and use it for whatever purpose (Frischmann 2004). The key point in the argument being that infrastructure creates not only its immediate economic outputs that can be captured through market transactions, but also a host of externalities - such as non-market and public goods that remain invisible to the traditional economic instruments. This allows us to adopt the following resource-based view of infrastructure (Frischmann 2012):

1. It is a resource that may be consumed non-rivalrously.
2. Social demand for this resource is driven primarily by downstream productive activity which require the resource as an input
3. This resource can be used as an input to a variety of productive processes - private goods, non-market goods and public goods.

There are two additional points to be made with respect to the above infrastructure qualifying criteria. First, it is clear that this definition would lead to the inclusion of natural resources into the definition of infrastructure. But, for purposes discussed in the section on infrastructure as a class of mature technologies, the discussion will be centred around human-made artefacts, which fulfil a designated function with the by-product of externalities. The existence of externalities opens up the important debate on whether or not infrastructure can be accessed non-rivalrously and to what extent does the resource-based view of infrastructure contradict the value appropriation

[9] As is generally the case in public-private partnerships (P3) or private-finance initiatives (PFI), which use separate legal entities (so called special purpose vehicles) to achieve economic efficiencies with execution as well as risk allocation.

reasoning inherent in the above-espoused business view of infrastructure. As the economic argument about rivalry has been developed elsewhere in great detail (e.g., Cornes and Sandler 1996), the focus of the present discussion will be on the different kinds of economic activity that the shared resource contributes to. Building upon Frischman's (2012) work on the demand-side of infrastructure governance as a commons, I would like to propose the following theoretical typology for the outcomes that that infrastructure projects should accomplish for their societies.

1. Providing nearly-non-rivalrous input into the production of private goods - commercial infrastructure
2. Providing nearly-non-rivalrous input into the production of public goods - public infrastructure
3. Providing nearly-non-rivalrous input into the production of social goods - social infrastructure

There are several important theoretical corollaries of the above resource-based view of infrastructure and its functions. The first one is the assumption that nearly-non-rivalrous access to the resource is possible. If the use of the resource becomes rivalrous, there will be a disincentive to share it and therefore it will be better governed as a private good. Conversely, shared and non-rivalrous resources can be used for many different purposes and therefore there will be an inherent information problem in determining and managing the demand for such resources. If we understand infrastructure assets as high-capacity shared resources, the governance focus will be on avoiding the overuse leading to depletion (Ostrom 2008). As central government control has shown to have produced similar failures, the common approach is to revert to the open market as the governing force which will avoid the 'tragedy of the commons', but with this approach externalities will feature only marginally (if at all) in the governance model as utility maximisation (in the form of revenue value capture) is likely to be the primary focus if not regulated (Frischmann 2012). Amongst other reasons, this is because the externalities (such as non-market and public outcomes that infrastructure projects contribute to) will remain by and large invisible to the traditional economic instruments. As a result, focusing narrowly on the value appropriation (as in the business model reasoning) will have the consequence of overemphasising the commercial project outcomes and underplaying the public and social outcome creation will remain un-appropriable for the value chain operating in notional open markets[10]. The dilemma between avoiding the tragedy of the commons created through central government control mechanisms on the one hand, and the degeneration of value creation into commercial value appropriation as in private-driven models on the other, suggests the need that both mechanisms should complement each other as is in various forms of P3 models.

This point brings us to the implications for governance and management of infrastructure projects as vehicles to deliver shared resources. First of all, it can be argued that there needs to be some level of government regulation in the space of infrastructure provision. The argument can go further, when different kinds of value generation mechanisms in infrastructure projects are taken into consideration. One of

[10] This is because a commercial entity will primarily be utility-driven and not driven by maximising positive externalities that the activity is producing. Along the lines of this rationale, what's best for the individual (human) or legal entity (as in a firm or organisation) will not necessarily lead to what is best for the society.

the important implications is the departure from the argument that public value and social value can be reduced to commercial value to acknowledge the importance of public governance and institutions that regulate behaviour of societies (e.g., Henisz et al. 2012, Scott 2013). In such a way the argument for resource-based view of infrastructure becomes more of a social institutionalist one (Scott 2013) than primarily an economic one (Williamson 1985). In light of this insight, the main question for policy is about the proportion of infrastructure projects that should be funded through long-term user charges as opposed to various forms of tax. The question for investors becomes, what proportion of the project could (or should) be seen as an investment with long-term financial yield (Monk et al. 2017) and what proportion should be seen as externality-creating - and therefore subsidised by government grants (Frischmann 2004).

This leads to the final note about finance and governance of infrastructure projects as vehicles for the delivery of shared resources. Along the lines of the reasoning that markets can generate economic efficiencies for infrastructure provision (as in the P3 procurement route), it can be tempting to overlook the positive and negative externalities which come as a by-product of commercial value capture that will be centre stage for the private actors in the supply chain. The role of governments should therefore be to consider project options on the table for the various kinds of outputs in the feasibility stage. To fail to do so would imply that only commercial outputs are generated, which then would turn the asset produced by a project into a private good - rather than a shared resource[11]. In the long run, this situation would lead to the disappearance of infrastructure as a human-made shared resource together with revenue generating potential it brings for the private sector.

VALUE DESTRUCTION PATHOLOGIES IN INFRASTRUCTURE PROJECTS

The question to be asked after presenting the different theoretical perspectives on infrastructure can be - how does it relate to the planning, financing, design, and execution decisions for respective projects. To develop the appropriate set of recommendations in light of the project as the main unit of analysis, the three theoretical angles presented previously (technology-, business-, and resource-focused views) will be combined with research on organisation design (Simon 1969/1996, Galbraith 1974, Levitt et al. 1999, Gruber et al. 2015), and projects (e.g., Morris 2013, Artto et al. 2015, Davies et al. 2016). The aim of this effort is to expand the understanding of value mechanics as infrastructure moves downstream in its lifecycle from project inception across construction and delivery to operations and use. If projects are conceptualised as temporary organisations that follow the trajectory of the product development lifecycle (Lundin and Söderholm 1995), then value mechanics can be understood in the (1) front-end project stage - where strategic decisions about the project are made, (2) execution stage with the main focus of delivering the project and handover whilst managing change, and (3) operations and

[11] When this happens, the market indeed becomes the most efficient resource allocation mechanism and the need for government intervention in the form of regulation and policy measures will become largely unnecessary. In such a way the situation of underplaying the social and public outcomes of projects can lead to a self-fulfilling prophecy in which assets are only seen through their short-term commercial outcomes and revenue generation potential - even further decreasing the role of governments and emphasising

use, as the long-term value creation and capture period. If, as previously discussed, infrastructure projects create value by (a) generating solutions for large-scale problems, (b) enabling the capture of value within the project delivery coalition and supply chains and (c) create significant positive externalities with non-market and social spillover effects, this provides an analytical structure for a value destruction typology that is next presented (Table 1).

	Front-end	Execution	Operations and use
Technology view	T1- Developing more infrastructure as the ultimate goal	T2 - Collective action problem	T3 - Not performing the designed functions
Business view	B1 - Competition only focus in the procurement process	B2 - Value extraction business model - war of all against all. Project value cannibalised.	B3 - No value capture - 'white elephant' liability
Resource view	R1 - Project brief does not contain public and non-market outcomes.	R2 - Deciding to build wrong projects - commercial benefits only rather than externalities	R3 -Tragedy of the commons or degeneration into private good

Table 1 - Propositional typology of value destruction patterns in infrastructure projects.

This preliminary typology of value destruction patterns can be understood as breakdowns in the rationale that understands infrastructure projects in light of technologies, businesses, and shared resources. The set of pathologies inherent to the technology view is one which does not address the means-ends rationale of design and the problem solving nature of the development. In this situation, the technology view of infrastructure would degenerate into one where (T1) the only goal is to develop more infrastructure without regard to the large-scale problem that the project should help solve, (T2) decisions are not being made primarily with the problem-solving purpose but are being driven by power relations in the stakeholder coalition leading to (T3) assets which depart from their brief and the functions they were designed to perform. A similar typology is at play with the business view of infrastructure focusing on value capture capabilities. This rationale can degenerate into the situation where (B1) the selection of the suppliers and the delivery coalition is made only on the basis of competition without taking into consideration long-term trust and quality implications of the transactional approach to procurement. This pattern will almost invariably lead to the (B2) pathology of value extraction in project execution, where one party benefits at the detriment of the other leading to a 'war of all against all' situation on the supply side. The final pathology of the business view on infrastructure is the (B3) inability of the supply chain to capture value from downstream operations and use of the project. This is often the case when the project is structurally (contractually and organisationally) detached from the operations of the asset. The resource-based view of infrastructure similarly yields three theoretical pathologies of value destruction patterns. This can be the case (R1) when the positive externalities are taken for granted (and therefore underplayed) in an attempt to find

the best commercial model in the procurement processes at the front-end of projects. The same issue is effectively carried forward as an execution pathology (R2) whereby wrong projects get built because of the desire to maximise the commercial outcomes as opposed to finding a balance across commercial, social, and non-market outcomes. Finally, if the control of the asset post-handover is either entirely with the commercial party or centralised state bureaucracy, this the resource is likely to degenerate into a (R3) private commodity with access restrictions, or into the 'tragedy of the commons' leading to overexploitation and depletion due to non-cooperative behaviours of self interest seeking users.

The preliminary typology of value destruction patterns can be helpful in the strategic selection of infrastructure projects due to their importance for infrastructure services provision and path dependency of decisions[12]. The typology can also be useful in assessing the risks across various projects in a strategic programme or a portfolio of discrete project investments that institutional investors such as pension funds and sovereign wealth funds might be interested in. Although traditionally execution risks have been understood as the major obstacle in making these investments, the analysis in this paper suggests that neither front-end nor the operational risks are negligible in light of identified value destruction patterns.

DISCUSSION AND CONCLUSIONS

The main point of departure for this paper is the need to disentangle the complexity of infrastructure as a domain of inquiry and practices. Argument developed in the paper suggests that infrastructure as a domain of inquiry is as a combination of political, strategic, and business interests tensions, the project as a resolution of these tensions and the long-term use value aspects feeding back into the decision cycle. Value generation mechanisms are following a similar definition and execution path as in new product development contexts, whereby the political and strategic promise act as a frame for the execution decisions which are enacted in the form of the project delivery coalition whose responsibility is project handover for use. In the setting of urban transportation infrastructure, such decisions can be motivated with ideas from economic and urban geography such as the premise of agglomeration economies. This premise suggests that improving the connectivity of businesses, individuals and industries in urban zones is expected to generate productivity increases which will generate local economic surpluses with spillover effects on a wider regional scale through tax and other economic redistribution mechanisms.

Such is often the political discourse to justify capital expenditures into large-scale infrastructure investments, which governments participate in to various degrees. There has been a recent push towards the provision of assets through various forms of public-private partnerships (P3), for which it is essential to understand the relation between the short term capital expenditures as well as long-term outcomes that will be generated by those investments. In practice, getting the private (or institutional) investors on board in early stages of infrastructure projects has proven difficult due to the high risks associated with the execution and delivery of such projects.

[12] Once a decision to build the wrong project is made and after resources are committed to the project, there is very little opportunity to reverse the decision and effectively the only choice left is to 'plow through'.

The aim of the paper was to develop a conceptual framework for understanding infrastructure as a domain of cross-disciplinary inquiry in general and infrastructure projects as a unit of analysis in particular. By drawing upon a diverse body of work in technology and design studies, business studies and neo-institutional economics, the paper derives a set of working propositions pointing towards infrastructure projects as vehicles to develop mature technologies, business systems, and shared resources as the three important functions that infrastructure performs for the society. Integrating this theoretical framework with the extant studies on projects as temporary organisations and systems lifecycle value creation, the paper then derived a propositional typology of resulting value destruction patterns. These patterns can be seen as hypothetical situations, in which projects fail to generate and deliver value to their users - thus incapacitating the value capture processes further down the road. This can happen either in pre-execution domain, in the execution stage, or in the operational outcomes domain. Either of the pathologies will leave institutional investors with a non-performing illiquid asset and their clients with broken promises about the envisioned performance of their investments.

The utility of the propositional typology developed is that it allows for a greater conceptual clarity in understanding the value mechanics for infrastructure projects. Although the author contends that the explanatory value of the propositional typology of value destruction is by no means comprehensive, it can be seen as a valuable stepping stone for future research looking into the architecture of value creation in infrastructure projects. The anticipated contribution of this stream of research is an endeavour to rethink the performance and success of infrastructure projects by moving away from the productivity-driven discourses and into a cross-disciplinary and value-driven discourse that compares how value is created, delivered, distributed and captured across the key actors in infrastructure development decision making. The second anticipated contribution is to explore pathologies of market, political and operational failures all of which contribute to value destruction and inability of players in the value chain of provision and use to generate and capture value in whatever form.

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