Research in Transportation Economics 90 (2021) 101069

Contents lists available at ScienceDirect

Research in Transportation Economics

journal homepage: http://www.elsevier.com/locate/retrec

A procurement policy-making pathway to future-proof large-scale transport infrastructure assets

Peter E.D. Love [a,*], Lavagnon A. Ika [b], Jane Matthews [c], Xinjian Li [a], Weili Fang [d]

[a] School of Civil and Mechanical Engineering, Curtin University, GPO Box U1987, Perth, WA 6845, Australia
[b] Telfer School of Management, University of Ottawa, 55 Laurier Avenue East, Ottawa, Ontario, KIN 6N5, Canada
[c] School of Architecture and Building, Deakin University, Geelong Waterfront Campus, Geelong, VIC 3220, Australia
[d] Department of Building, School of Design and Environment, National University of Singapore, 4 Architecture Dr., 117566 Singapore

ARTICLE INFO

Keywords:
Australia
Assets
Policy-making pathway
Procurement
Future-proofing

ABSTRACT

Governments worldwide have made a significant financial commitment to combat increasing traffic congestion and ageing transport networks over the next decade. However, large-scale transport projects are often late, over-budget, and below quality, making it difficult to future-proof assets and accommodate unanticipated changes. Evidence indicates that the traditional procurement model for large-scale projects used by Australian State Governments, for example, fails to deliver expected benefits. Markedly, a focused policy-making pathway is absent, especially for future-proofing these complex projects. Hence, the need to move away from a prevailing 'understand, reduce, respond' to a more adequate 'understand, embrace, adapt' attitude towards complexity and uncertainty in project procurement. The enabling functions of asset management, digitization, delivery, and finance might help. However, little is known about how they can coalesce to form a policy-making pathway to provide governments value for money outcomes and ensure assets are future-proofed. In this paper, we fill this void by reviewing the normative literature and proposing a conceptual approach. The issues we examine are of the utmost interest to governments worldwide as they grapple with designing, constructing, operating and maintaining transport assets that are both resilient to unexpected events and adaptable to changing needs, uses or capacities including climate change.

1. Introduction

"We see the procurement side of the construction industry squeezed on margin, higher risk, and project blow-ups. The model we've traditionally used is broken." Maria Atkinson AM GAICD (Niesche, 2019).

While Maria Atkinson's comments are explicitly relevant to the Australian construction industry, these same sentiments have resonated throughout many economies worldwide over the last seventy years (e.g., Simon Committee Report; 1944; Banwell Report, 1964; Commonwealth of Australia, 1991; Latham, 1994; Kommerskollegium, 1996; KTM, 1996; Egan, 1998; Construct 21, 2000). Indeed, the construction of large-scale transport infrastructure projects (>$500 million) have been particularly impacted by procurement practices, which still focus on the use of 20th Century practices and processes that are unable to effectively support the use of technology and accommodate the inherent complexity and uncertainty associated with their delivery (Love et al., 2020). The corollary, we contend, is an inability to deliver transport assets that provide sustainable economic and social benefits over their intended life (Love, Ika, et al., 2018a).

Notwithstanding, transport infrastructure (i.e., passenger and freight) provides the backbone for an economy to prosper both economically and socially. Increasing demographic, technological, economic and social changes, however, places considerable strains on existing transport infrastructure. Consequently, in many countries worldwide including Australia, which inspires this policy-focused paper, we have seen traffic congestion increasing, ageing public transport networks not being upgraded, and airport facilities unable to cope with growing passenger and freight demands (Sosoff, 2014; Terrill, 2017, 2019). Such shortcomings not only adversely impact a country's productivity but also its economic and social well-being (Sosoff, 2014; Infrastructure Australia, 2019). Throughout the world, many countries such as Australia, the United Kingdom (UK) and United States (US), are

* Corresponding author.
E-mail addresses: p.love@curtin.edu.au (P.E.D. Love), ika@telfer.uottawa.ca (L.A. Ika), jane.matthews@deakin.edu.au (J. Matthews), xinjian.li@curtin.edu.au (X. Li), weili_f@hust.edu.cn (W. Fang).

https://doi.org/10.1016/j.retrec.2021.101069
Received 29 September 2020; Received in revised form 28 January 2021; Accepted 2 April 2021
Available online 13 April 2021

experiencing problems with the procurement of their transport infrastructure networks and systems (Mills et al., 2011; Goulden et al., 2014; Council on Foreign Relations, 2016; ACA, 2017).

Australian governments, like their counterparts in Europe and in North America, are aware that there is an absence of quality gateway and corridor infrastructure (e.g., TRB, 2019; Transport Canada, 2020; Infrastructure & Projects Authority, 2020 June 2020). Thus, governments have been trying to tackle this problem by financially committing to upgrade, maintain and construct new transport assets over the last decade. For example, in April 2021, the Biden Government proposed a 2 trillion infrastruture plan in the US "to build back better". In 2020, the US Secretary of Transportation Elaine L. Chao announced that $1 billion will be invested to repair, rebuild, and revitalize transportation systems (Global Railway Review, 2020). Between 2017 and 2020, a total of $4 billion worth of funding has been allocated to support the construction of new roads, bridges, rail, and ports in the US (Global Railway Review, 2020). The Canadian Government, for instance, in its 2017 budget proposed to invest $10.1 billion over the next decade in trade and transportation projects (Government of Canada, 2017). The aim is to build more efficient transportation corridors to international markets and help businesses compete, grow and create employment.

Meanwhile on the other side of the world, the incumbent Commonwealth Government in Australia, for example, made an announcement in its "2019 budget to invest $100 billion over 10 years from 2019 to 20 in transport infrastructure, which includes an additional $23 billion for new projects and initiatives" to combat congestion, better connect regional areas, and improve road safety and the quality of the freight network (Commonwealth of Infrastructure Australia, 2019, p. 2). Significant funds, for example, have been directed toward major projects in Victoria such as the AU$15.3 billion Melbourne's East West Link and the AU $50 billion Suburban Rail Loop, to name but a few.

Despite the significant amount of investment in transport infrastructure, there is a tendency for large-scale projects to be delivered late, over-budget, and below their desired quality (Coultan, 2016; Catalão et al., 2019; Cavalieri et al., 2019; Kuspura, 2018; Moschouli et al., 2019; Niesche, 2019; Terill & Danks, 2016; Turró & Penyalver, 2019). Admittedly, the query – why so many projects fail – remains a long-standing puzzle in theory (Gil & Pinto, 2018). In practice, however, regardless of the answer, policy-makers ask: *What can be done differently to improve the performance of large-scale transport infrastructure projects*? Tackling this practical question, we argue, is undoubtedly a daunting task. Indeed, the backlog of transport infrastructure juxtaposed with the realization that projects, particularly those of a large-scale and/or a complex nature, are prone to cost and schedule overruns, exacerbates the ability of governments to provide services for the movement of freight and connect people to their jobs, communities and essential facilities.

We now specifically refer to the Australian context but the issues raised pose similar challenges to many developed economies. When governments develop their transport procurement policies, they tend to overlook the voices of concern from the private sector as they still proceed to use traditional forms of procurement (Love et al., 2020). Listening to the concerns that have been raised by the Australian Constructors Association (ACA, 2017) and Australian Group of Company Directors (Niesche, 2019) and taking into consideration the numerous large-scale transport projects whose performance (i.e., time, cost and quality) has been adversely impacted, we can unequivocally conclude that the traditional procurement model used by governments is *kaput*.

It is outside the scope of this paper to explain why governments have continued to use traditional approaches despite their failings, but we suspect that the drive to obtain the lowest price and minimize risks has overshadowed their ability to work collaboratively and deliver value in their large-scale transport projects. Evidence of such issues occurred in projects such as the Gold Coast's Light Rail Transit (LRT) (Coultan, 2016), Sydney's LTR (O'Sullivan, 2018; Sas, 2019), and Perth's Forrestfield Airport Link (Evans, 2016; Flint, 2019).

In this paper, we focus on the fact that the traditional *modus operandi* for procuring large-scale transport projects is not only unable to accommodate the political (e.g., change in governments), social (e.g., population growth), economic (e.g., productivity levels) and environmental (e.g., climate change) complexities and uncertainties associated with their delivery but also to 'future-proof' the constructed assets cost effectively (ACA, 2017; Bowditch, 2013; Davies, 2014; Love, Ika, et al., 2018; b). We acknowledge that the need to enact changes to existing policies for procuring large-scale transport projects has been recognized by governments and industry in Australia in particular (Productivity Commission, 2014: ACA, 2017; Wiggins & Ludlow, 2018). While the transport policies adopted by Australian State Governments for "their respective capital cities have been similar in nature indicating the almost seamless transfer of concepts" (Bray et al. 2011, p. 522), there is limited evidence to suggest that procurement strategies and processes have followed a comparable path (Rahmani et al., 2017).

To address this pervasive problem, we therefore suggest there is a need to re-examine and transform the traditional way of procurement for projects. Accordingly, we proffer that if we are to stand any chance to deliver efficiently, effectively and resiliently transport infrastructure projects, we should move away from an "understand, reduce, respond" (Maylor & Turner, 2017) to what we label an "understand, embrace, adapt" attitude towards complexity and uncertainty (Hirschman, 1967; Lyons & Davidson, 2016). Without such a change in attitude, we note that the development of a policy pathway or a "series of elements that contribute to determination of policy or investment decision" (Lyons & Davidson, 2016, p. 105) for the procurement of large-scale transport infrastructure projects is doomed to fail. As these authors suggest, "policy-makers have a responsibility to consider the type of pathway best suited to evolving the transport system" (p.105).

To help policy-makers make the best-fit choices and adequately respond to the challenge for governments to invest and deliver new efficient, effective and resilient large-scale transport projects, we argue for the need of a dedicated procurement policy-making pathway for large-scale transport projects. Governments have tended to shoehorn the procurement of their transport projects under the umbrella of a one-size-fits-all policy, ignoring the fact that those of a large-scale and/or complex nature have special needs and demands (Love et al., 2020).

With this in mind, we review the normative literature and propose a conceptual framework to create a procurement policy-making pathway in order to deliver large-scale transport projects. According to Love et al. (2017), a focus on the following enabling functions of a transport project's procurement process is needed to future-proof assets: (1) asset management; (2) digitization; (3) delivery; and (4) finance. However, there have been limited studies that have sought to inform governments about how these enablers can coalesce to form a policy-making pathway to provide outcomes that generate value for money and help future-proof assets.

We fill this void in this paper by suggesting there is a need for governments to develop a clear-cut policy-making pathway for the procurement of large-scale projects so that they create a mindfulness to absorb and proactively respond to unexpected events and climate change. The issues we bring to the fore in our paper will be of the utmost interest to governments worldwide as they grapple with designing, constructing, operating and maintaining transport assets that are both resilient to unexpected events and adaptable to changing needs, uses or capacities, not to mention climate change.

2. Procurement of large-scale transport infrastructure assets

Ensuring transport projects meet their baseline time, cost and quality objectives is a vexing problem for state governments in Australia (Terill & Danks, 2016). It has also been an issue for other countries worldwide such as Norway, Italy, and Portugal, to name but a few (e.g., Catalão et al., 2019; Cavalieri et al., 2019; Odeck, 2004). As a project's baseline cost begins to derail from what has been estimated at its decision-to-build, the ability to future-proof an asset diminishes. Decisions are, therefore, often made to modify the project's scope and specifications to reduce construction costs (e.g., alternative specifications and materials). Such actions, however, can have the opposite of the desired effect as the costs of maintenance are overlooked. Indeed, the decision-makers focus simply on delivering the project within budget rather than taking a life-cycle perspective of project costs (Love et al., 2017; Liu *et al.*, 2019).

If the process to procure large-scale transport assets is to significantly improve, then we need to re-examine the nature of strategic risks and the conditions (e.g., procurement framework) that form the basis for a project's environment. A report commissioned by the Australian Constructors Association (ACA, 2017), for example, has recognized that the traditional management and procurement practices used for mega-projects are not able to accommodate the political, social, economic and environmental complexities associated with them. Table 1 provides a summary of a behavioural model proposed by the ACA (2017) to address cost overruns in mega-projects. A key feature of this behavioural model is the building of a performance culture where collaboration is the focus and complexity is addressed by decomposing a project into smaller manageable parts.

The Level Crossing Removal (LXR) Project in Melbourne (see https://levelcrossings.vic.gov.au/), a program alliance, is a good example of a mega-project which has been broken down into a series of smaller projects in order to deal with its overall complexity. In many ways, the ACA's proposed model aligns with the features of characteristics of alliance-based procurement, which we address below in Section 3.3. Breaking down a mega-project into smaller projects, however, to deal with its complexity and uncertainty is akin to adopting an 'understand, reduce, respond' attitude (Maylor & Turner, 2017). In true complexity and uncertainty thinking tradition, we know that one size does not fit all transport projects and that some projects are not as simple as they appear but others are not as complex as they seem (Giesen, 2012). Thus, we believe there is another way forward. Notably, in the changing socio-political environment, complexity and uncertainty are not necessary problems but also opportunities and thus we ought to adopt a different attitude: 'understand, embrace, adapt' (Hirschman, 1967; Lyons & Davidson, 2016).

Frankly, governments have a duty and responsibility to provide their citizens with transport assets that are adaptable and responsive to changes in climate, increasing population and usages. As a result, there is a need to overhaul their procurement policies to future-proof their transport assets. For example, engaging in unsolicited bids processes such as those adopted by the New South Wales government for the $2.9 billion NorthConnex project in Sydney. Soliciting bids for a large-scale transport project is a costly exercise for the contractors/consortium, especially as losing bidders are likely not to receive a fee for their submission. For projects over AU$500 million, the cost to submit a bid can range from 3% to 5% of a project's value, which represents a significant cash investment for the chance of winning a project (Productivity Commission, 2014, p. 452). A significant change in Public Private Partnership (PPP) policy has occurred in the treatment of bid costs, which in the past was a marketing cost borne by bidders. In 2013, the Victorian Government foreshadowed part or full reimbursement of bid costs for future PPP projects albeit for losing syndicates responding to invitations for a request for tender.

Table 1
Elements of the ACA's proposed behavioural model.

Element	Description
Engaging the eco-systems	Projects are required to address a diverse range of stakeholders needs. Therefore, people and social needs will have to be accommodated using supporting processes and technologies.
Enabling innovative solutions	Engineering and contracting models need to be able to engender continuous innovation rather than being too rigidly specified upfront in an ineffective attempt to reduce risk.
Architecting complex change	Complex projects will need to be broken into smaller, manageable parts. Managing such projects requires a focus on managing human change as well as the engineering that is needed.
Building a performance culture	A culture of collaboration should be developed across a project's supply chain to enable optimal decisions to be made locally instead of relying on centralized control.
Aligning business models	New projects need contract models that align outcomes across a broader range of stakeholders, and are also adaptive and responsive to the dynamic work environment.
Changing leaders	There is a need to change the capability focus of project leaders and leadership from task management to achieving political, social, and economic outcomes.
Learning agility	Learning needs to be embraced during and between projects so new processes and procedures can be adapted to different project outcomes

Adapted from ACA (2017:p.19).

A robust procurement policy-making pathway to handle the complexity and uncertainty that is being placed on transport infrastructure as a result of political, economic, environmental and social changes is required. In practice, an array of different pathways exists, which are often intertwined with one another. However, Lyons and Davidson (2016) cogently distinguish between pathways that place "implicit reliance on the way of the world as we have known it" (i.e., regime-compliant) and those that "embrace uncertainty" (i.e., regime-testing) (p.113).

In the context of procurement, the regime-compliant policy-making pathway, has a limited appetite to deviate from the status quo, and "is based on misplaced confidence and reliance on historic cause-effects relations and forward assumptions" (Lyons & Davidson, 2016, p. 114). Moreover, this type of pathway is over-reliant on using information to justify decisions, which generally leads to a reactive policy-making. The adoption of a hasty policy in this instance is likely to fail as it will be unable to accommodate "unanticipated change" (Lyons & Davidson, 2016, p. 114). In this case, the failure materializes as a consequence of the public sector agency using traditional procurement strategies to deliver their large-scale transport assets, as we highlighted above. By failure, we mean project cost and schedule overruns, quality failures and benefit shortfalls that may arise during an asset's operation and maintenance. Examples of large-scale transport projects failing to meet their expected deliverables and service quality are abounding.

A case in point is Delhi's Airport Metro Express (DAME), which was supposed to be completed and operational for the Commonwealth Games in October 2010, but instead did not commence operations until February 2011 (Li & Love, 2020). Then, between July 2012 and January 2013, the line had to be closed due to an 'unanticipated event'; that is, defective civil engineering works. The DAME was a PPP project and the closure of the line resulted in revenue losses experienced by the private sector. The PPP contract was terminated and therefore the public sector had to take responsibility for the line's operation and pay compensation to the private sector (Li & Love, 2020).

3. Procurement policy-making pathway

Like many economies, Australia is confronted with unprecedented levels of uncertainty exacerbated by climate change and population growth. Thus, if state governments are to respond and adapt to change effectively, then they ought to possess a willingness to discount "historic cause-effect relations" so that they can accommodate "unknowns" into their project decision-making processes (Lyons & Davidson, 2016, p. 114). The development of a procurement policy-making pathway that seeks success yet embraces failure in projects, not as an outcome to avoid but instead an opportunity to learn, requires governments to possess mindfulness to absorb and proactively respond to a "discrete environmental jolt" (Williams et al., 2017, p. 740).

Unfortunately, politics often gets in the way of policy-making and myopic decisions may be made to suit an incumbent government's agenda. For example, in the 2019 Federal elections in Australia, both the Coalition and Labor parties promised to bolster spending on transport infrastructure with investments of AU$42 and AU$49 billion, respectively (Moran & Ha, 2019). Significant funds, for example, were directed at major projects in Victoria in places such as Melbourne including the East West Link and Suburban Rail Loop. Moreover, we saw the Coalition "sandbagging" key seats by making commitments to local projects, for example, AU$300 million worth of roads and additional railway stations (Wright & Irvine, 2019).

We are cognizant that politicians like to announce big projects, which, as media magnets, give them visibility. However, projects are announced without their technical details being investigated. As a result, politicians have little idea about the real costs of the projects that they announce. The announced figure is almost always lower than the final constructed cost. For example, the Level Crossing Removal project in Melbourne was announced to cost AU$6 billion in 2014, but the real cost will be over AU$15 billion. Similarly, in 2014, the West Gate Tunnel was announced to cost AU$ ½ billion but now has risen to AU$6.7 billion (Lucas and Jacks, 2019).

As we mentioned in the introduction, there are four key enablers that can contribute to future-proofing transport assets (Love et al., 2017). However, Love et al. (2017) only provide a cursory glance at the roles of these enablers and did not put forth how they can be used to drive a specific procurement policy-making pathway to deliver projects. Building on the work of Love et al. (2017) and the UK's Construction Industry Council's (2014) vision for a digital future, we present a conceptualization of our procurement policy-making pathway in Fig. 1 and provide a brief description of the proposed new views for the enablers identified by Love et al. (2017) in Table 2, which are discussed in detail below.

Underpinning these enabling elements is the deployment of disruptive technologies (e.g., artificial intelligence, blockchains, Internet of Things (IoT), three-dimensional (3D)-printing and advanced virtual reality). Such technologies can facilitate the redefinition and restructuration of the supply chains that have been traditionally used to deliver transport assets. Thus, the process of delivering 'value' is transformed. Governments need to include an explicit contractual requirement for the use of disruptive technologies throughout all phases of a project's life-cycle.

Having in place disruptive technologies will give governments access to previously unavailable data. As a consequence, governments can be provided with data throughout each phase of an asset's life-cycle, which will inform and shape their decision-making, particularly during the operations and maintenance phases. At this juncture, we suggest that projects should be delivered with 'Private Participation in Infrastructure (PPI)'. Moreover, we proffer that contracts should be 'bundled' rather than 'unbundled' so as to ensure contractual continuity during operations and maintenance, which is referred to as the partnering phase in Fig. 2. We explain our call for the use of a 'bundled contract' in greater detail in Section 3.3 below.

In Fig. 2, we identify the key drivers of transport infrastructure projects. They include sustainability (e.g., pollution and environmental degradation), urbanization (e.g., congestion and population) and economic stimulus (e.g., employment and movement of goods and services). At each phase of an asset's procurement life-cycle (e.g., initiating and planning), we suggest that the public sector implements performance measurement to ensure activities align with drivers and deliver expected outcomes. In the face of varying economic, environmental and social needs, having performance measures in place gives the public sector the ability to respond and adapt to change (Liu *et al.*, 2020). Digital technologies are key to managing a project's performance, as information can be instantly used in real time to provide instant feedback and thus improve decision-making. A decision based on (historic) information that is "not instantaneous, is sticky" (Construction Industry Council, 2014, p. 9). Thus, such a decision is made based on information

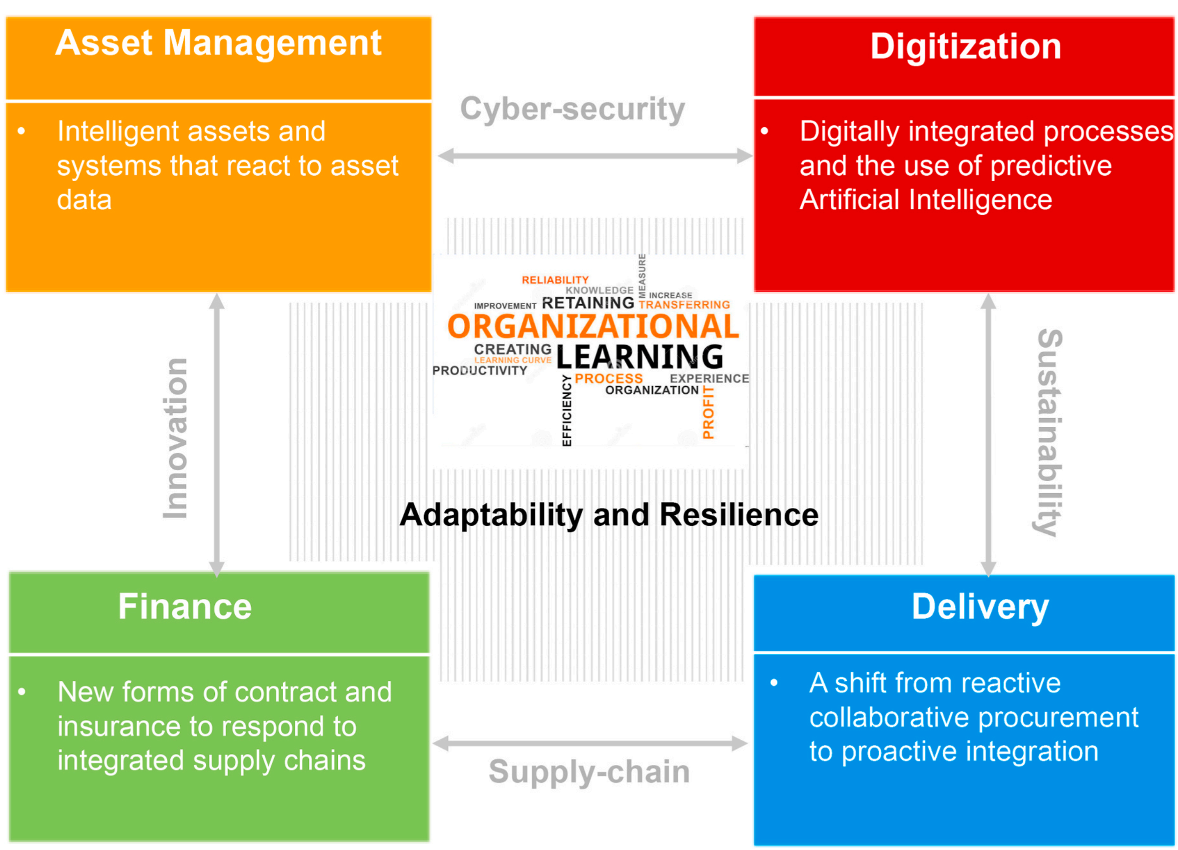

Fig. 1. Conceptualization of a procurement policy-making pathway: Enabling strategies to future-proof large-scale transport assets.

Table 2
Comparison between the 'new' and 'traditional' views of procurement enablers.

Enabler	New View	Old View
Asset Management	• Intelligent assets and systems that react to asset data (predictive and reliability centred maintenance) • Asset management commences during the initiation and planning process • Carbon costing of asset life-cycle procurement	• Breakdown and preventative maintenance • Operations and maintenance commence at the hand-over of an asset • Discount whole-life costs and focus on cost minimization • Information incomplete at handover. Documentation contains errors and omissions and typically in a paper format.
Digitization	• Digitally integrated processes, structured data and the use of Artificial Intelligence for predictive and prescriptive analytics • Smart data for decision-making • Asset connectivity	• Reactive decision-making at each phase of the procurement process and re-evaluation of data. • While digital technologies are present there is a lack of interoperability resulting in tools and processes being dis-connected • Traditional analogue based tools
Delivery	• A shift from reactive collaborative procurement to proactive integration • Focus on the creation of *shared* value, risks and leadership • Bundled contracts (i.e., seamless flow information) • Multi-party contracts (e.g., alliancing)	• Absence of supply chain integration between design, construction and operations • Unilateral focus on risk allocation (e.g., contractors assume design, construction, finance and operation risks) • Centralized leadership and single responsibility • Unbundled contracts (i.e., fragments of information)
Finance	• Focus on transactional experience and new forms of contract to respond to integrated supply chains. • Land value capture (development-based) • Blockchain and smart contracts (real-time payment)	• Project finance (i.e., demand risk) • Monthly payments pending valuations (i.e., impact on cashflow) • Standard forms of contract (i.e., unable to accommodate real-time payments) that are unable to accommodate collaboration and shared risk

Fig. 2. An example of the key phases for delivering a rail asset.

that is out-of-date. If projects are to embrace the *understand, embrace and adapt* attitude, as we previously noted, then information needs to be instantaneous for decision-making, which can be used to 'anticipate what might wrong' and improve how a project deals with uncertainties and risks.

In sum, having a procurement policy-making pathway that engenders the application of disruptive technologies will enable:

- the bestowing of transparency as costs and prices can be more accurately assessed;
- transactional procurement to be automated in part; and
- the development of pre-emptive risk mitigation strategies to ensure operations are optimized.

We now examine each of the enabling functions identified in Fig. 1 and their purpose within a procurement policy-making pathway.

3.1. Asset management

Governments deal with multiple assets that share common characteristics or resources. The management of transport assets is an inherently complex process, which involves varying agencies and functionalities to provide information that can be translated into continuous actions that enable (Lima & Costa, 2019): (1) an asset to generate value to the organization and its customers; (2) the strategic intent of the organization to be transformed into technical, economic and financial decisions; (3) managers to oversee and roll-out improvements in operations; and (4) the quality of assets to be assured.

Asset management involves the balancing of costs, opportunities and risks against the desired performance of assets, to achieve an owner's objectives (ISO 55000, 2014; Lima & Costa, 2019). Moreover, it enables asset owners, such as governments, to examine the need for and performance of their assets and respective systems at varying levels. Having appropriate and reliable information about an asset (e.g. product data, warranties and preventative maintenance schedule) is pivotal for enabling asset management to support the decision-making, planning and execution of activities and tasks of assets, particularly during operations and maintenance (Love, Zhou, et al., 2018b).

Asset owners typically request that their contractor at a project's practical completion hands over a complete set of 'as-built' documentation. Traditionally, the documentation has been handed over in a paper format or CAD (.dwg) file and then placed into storage where it is difficult to access, locate and amend when changes are needed. More surprisingly, however, even though it represents a contractual requirement at practical completion, 'as-built' documentation is often handed over late when an asset is 'in-use' (Teicholz, 2013).

With many asset owners having computer maintenance management systems (CMMS) and computer asset management systems (CAMS) in place, the information, which is contained within the 'as-builts' such as test sheets, vendor information, maintenance data, needs to be transferred into these systems. The process of transferring data from the 'as-built' documentation is undertaken manually, which is costly and time-consuming. The CMMS/CAMS are often not used until they contain all the necessary data, and it has been checked for accuracy and completeness (Teicholz, 2013). The cost and time associated with entering, verifying and updating information in these systems can be phenomenal for owners and operators. Also, legacy data issues are often a problem as often information is stored in a variety of different media. Such information does not always reflect the actual configurations of assets in that 'as-builts' are often not maintained or are poorly communicated (Gallaher et al., 2004).

3.1.1. Thinking of the end at the beginning: asset management

Traditionally, the function of asset management is enacted when transport infrastructure is constructed and operations commence. Seldom, if at all, are asset managers included in a project's initiation and planning process and maintenance requirements considered. Supporting this point, the Head of Technical Information at Crossrail (UK), Mr Malcolm Taylor, stated that "the world of maintenance is often paid lip service by designers, and the maintainers don't often push their requirements hard at a project level" (Wiggins, 2016).

In light of operation and maintenance costs significantly outweighing those of construction, asset managers must have a prominent role in the design process. Eschewing the involvement of asset management from a project's formative phases hinders the ability to prescribe a long-term maintenance requirement where a philosophy of repair rather than failure can be implemented. Equally, adequate consideration of whole-life costs is abated (Love, Zhou, et al., 2018). Failure jeopardizes an asset's integrity and can adversely impact productivity and safety. In a similar vein, playing down the economic importance of whole-life costs will adversely affect an asset's viability over time.

Against this contextual backdrop, we argue that the asset management function has a critical role in the future-proofing process of transport projects. The inclusion of asset management in the design process can alert designers to uncertainties that can manifest during the operation and maintenance of the asset. The presence of an asset manager during the initiation and planning phase provides the ability to build greater flexibility into the design of an asset and to evaluate a series of investment options.

Building flexibility into an asset's design provides the "means, should it ever be needed, to accommodate a possible but uncertain later development" (Lyons & Davidson, 2016, p.110). As these authors rightly note, "building in flexibility will typically introduce greater costs" (p.110). Such increased costs, may, at face value, be disconcerting but can result in value for money being realized during the asset's operation in the form of reduced maintenance expenditure. For example, during the construction of The Green Build at San Diego International Airport in the US, the Building Information Modelling (BIM) manager noted that "every dollar we spend in design we spend $50 to $60 in maintenance. If we can spend an extra dollar in design and save $10 in maintenance, that's a significant saving for us" (McGraw-Hill Construction, 2012: p17).

The asset manager would be responsible for structuring and managing the information needed from the initiating and planning and procurement processes (Fig. 2). The information would be collated in a digital format using a building information model (herein after model) to ensure asset can be effectively and efficiently maintained and it can operate with minimal disruption and downtime. The need for standardization (e.g., product and processes) and structured approach for managing information has been widely espoused in construction (e.g., Björk; Laakso, 2010; Gibb & Isack, 2001; Laakso & Kiviniemi, 2012; Roy et al., 2005; Tolman, 1999).

The Construction Operations Building Information Exchange (COBie), a non-proprietary data format for the publication of a subset of building information models, can be used to support the delivery of asset data as distinct from geometric information. The aim of producing information in a digital format for operations and maintenance is to use disruptive technologies effectively and create intelligent assets and systems that react to pertinent data. The use of Building Information Modelling (BIM) and COBie thus provides a segue for us to create a policy-making pathway for digitizing the procurement process.

3.2. Digitization

As we mentioned above, disruptive technologies need to underpin the mechanics of a procurement policy-making pathway for large-scale transport projects. Indeed, BIM is deemed to be a disruptive technology, and there is a broad acceptance across the construction industry that digital modelling can provide significant productivity and performance benefits. The use of BIM not only alters the traditional work practices and value pools for the organization charged with delivering a transport asset's, but also initiates changes to a government's procurement policy.

For example, acknowledging the value of BIM, the UK Government amongst others (e.g., China, Germany, Finland and Singapore), mandated its use for central government-funded projects in 2016, thus requiring them to be working at BIM Level 2 as a minimum. Underpinning the requirement for BIM is the UK Government's Construction Strategy (Infrastructure and Projects Authority, 2016). Supplementing this strategy is the 'Digital Built Britain' initiative that was launched in 2016 at the Institution of Civil Engineers BIM Conference (see https://www.gov.uk/government/news/launch-of-digital-built-britain), which aimed to deliver reductions in whole-life costs and carbon emissions, improve productivity, and reduce project costs by 20%, using intelligent building models.

The figure of 20% is arbitrary; no empirical evidence underpins this aim. Unfortunately, misleading goals of this nature have been used regularly to justify the need and drive for change in the way projects are delivered, particularly in the case of technology (Love & Matthews, 2019). A case in point in Australia is the 'Building 4.0 CRC' which aims to use "deep collaboration and new technologies of the 4th industrial age, and to catapult the industry into an efficient, connected and customer-centric future" (see https://www.building4pointzero.org/). As a result, employing new digital technologies, it is suggested will help deliver assets at a significantly lower cost. Besides ignoring to explain 'how' this can be achieved, a series of unrealistic quantifiable 'fictitious targets' are advocated to promote the benefits of digital technologies. For example, "30% reduction in projects costs through digital technology and off-site manufacturing", "40% reduction in project delays through integrated, live scheduling", and "80% reduction in construction waste and re-work". Such sensationalist claims demonstrate a "spirit of due negligence" (Tourish, 2019, p. 2).

It needs to be made clear here that we are by no means neo-Luddites, quite the contrary. We are, in fact, steadfast in our conviction that digitization is a key to engendering productivity and performance improvement throughout a transport project's supply chain and an asset's lifecycle. Selling the benefits, however, of digital technologies via the means of 'fictitious targets' not only artificially raises expectations of their likely benefits, but it also can result in underestimating the change needed to work practices, behaviours and culture in projects. From a policy perspective, digitization and change management must go hand-in-hand if the process of future-proofing assets is to produce meaningful benefits.

3.2.1. Mandating the digitization of transport assets

The UK Government is leading the charge with its digitization strategy. Indeed governments, worldwide, can learn from the UK's digitization policy. In Australia, there are no blanketed Commonwealth and State Government mandates for the use of BIM and other digital technologies (e.g., sensors for structural health monitoring). In 2016, however, the Australian Government's Standing Committee on Infrastructure, Transport and Cities recommended that the use of BIM be made compulsory on government-funded projects exceeding $50 million. Except for Queensland, which requires the use of BIM by 2023 in all new major government construction projects over $50 million (Bushell-Embling, 2018), State Governments in Australia have yet to take on board this recommendation and mandate the implementation of a digitization policy. Examples where a specified BIM deliverable on projects has occurred include the Sydney Metro Northwest (New South Wales), Forrestfield Airport Link in Perth (Western Australia), and Cross River Rail in Brisbane (Queensland), to name a few. While the seeds for mandating the use of BIM in Australia have been sown, its adoption remains stymied by a lack of a contract that supports its effective implementation (Alwash et al., 2017).

The implementation of BIM provides the platform for digitally integrating processes throughout a transport project's life-cycle. When BIM is coupled with AI, the performance and productivity benefits are boundless. For example, we can improve the design of constructed assets by using 'generative design' and implementing robots to autonomously capture 3D scans, which can then be fed into a deep learning network to determine a project's progress real-time.

Without having a structured and standardized data format in place that is enabled by BIM, the ability to realize the benefits of 3D printing, robotics, visualization, intelligent content extraction, predictive analytics, cognitive computing and AI may be forgone. This situation also applies to nascent digital technologies such as blockchain, cyber-tracking, and spatial analytics. Again, we reiterate the importance of introducing asset management into the design process so that emphasis can be placed on 'thinking of the end at the beginning'. The upshot in this instance is that the needs and requirements to future-proof an asset can be given consideration and accounted for at a project's onset.

To facilitate the adoption of BIM, we present a digital workflow in Fig. 3. In this figure, we can see that, at the beginning of a project, its scope and the processes used to support the creation and collation of information required to future-proof an asset are underpinned by a BIM execution plan and COBie.

The BIM execution plan facilitates the management of information in a project. It is defined by PAS 1192–2:2013 as a "plan prepared by the suppliers to explain how information modelling aspects will be carried out". A PAS is a Publicly Available Specification that acts as a guidance document. The PAS 1192–2 was developed on the existing code of practice for the collaborative production of architectural, engineering and construction information, defined by BS 1192:2007 (now replaced by BS EN ISO 19650). PAS 1192–2 focuses specifically on project delivery. Its application begins with the needs statement and works

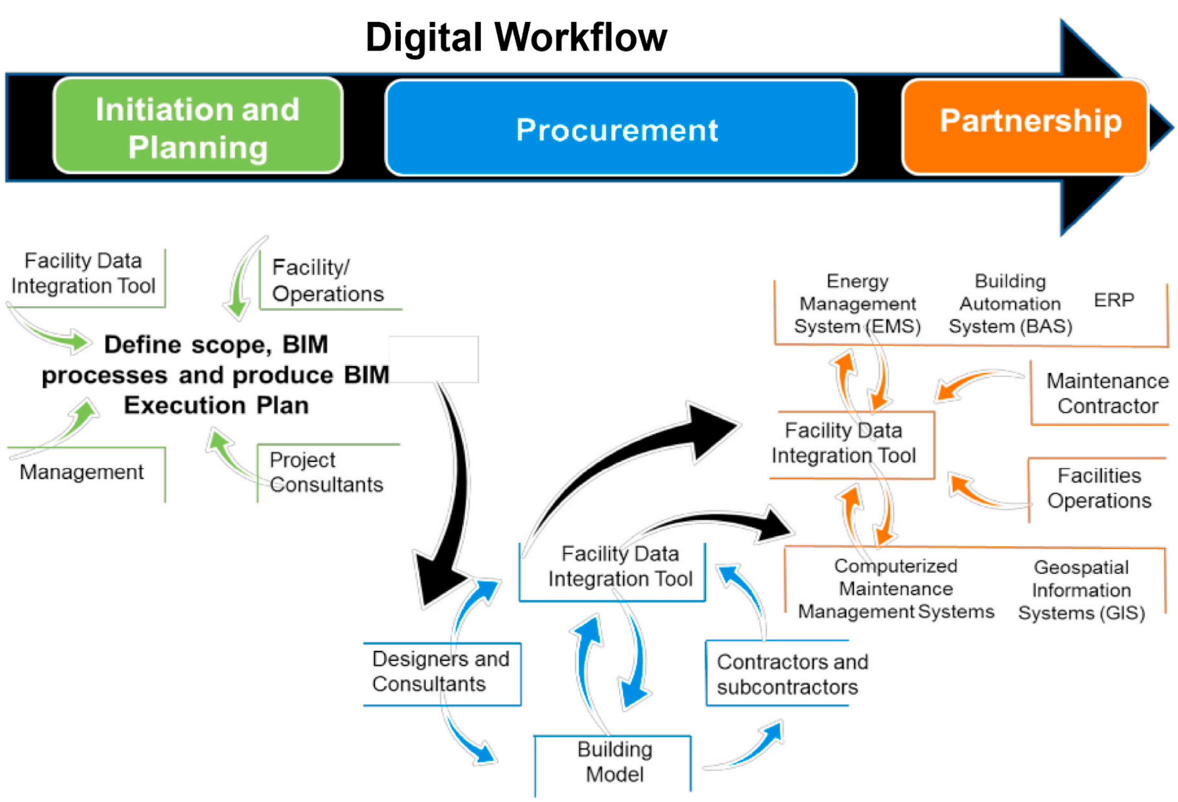

Fig. 3. Example of a digital workflowSource
Love et al. (2015: p.29).

through the stages of the information delivery cycle, culminating in an 'as-built' model for asset management.

The model and the information contained within it should be able to integrate with the owner's/operator's asset/facility management systems. In the case of rail projects, for example, electrical, control, instrumentation and control systems (ECIS) are critical for operating a network. However, for rail projects, the ECIS documentation that is provided to asset owners is almost always handed over, containing errors, omissions and considerable information redundancy (Love et al., 2016, 2018b). What's more, complex connected systems such as ECIS are unable to be modeled in a 3D environment as they do not possess geometry.

Therefore, creating a digital model for the use of ECIS during the operations and maintenance of rail networks has been a challenge for Australian transport authorities. For example, research undertaken by Love, Zhou, et al. (2018) demonstrated that the disruptive technology of Systems Information Modelling (SIM) can be used to create a digital model of ECIS and then be integrated with the Perth Transport Authority's asset management software system (i.e., Ellipse), which is akin to a CMMS. Furthermore, objects modeled in a SIM environment have a 1:1 relationship with the objects in the physical system, and components, connections and functions are defined and linked as they would be in the real world. As a consequence, a digital twin for ECIS can be created (Love & Matthews, 2019).

To this end, we suggest that the Australian Commonwealth and State Governments work in unison to mandate the use of digital modelling in transport projects in order to enable processes to be integrated throughout their life-cycle. Governments need to be mindful that there are, however, intended and unintended effects of mandating the use of digital technologies. On one hand, the benefits of the digitization of the procurement process of large-scale transport projects include reductions in capital expenditure (CAPEX), operational expenditure (OPEX), CO_2 emissions, improved service quality, and resilient and adaptable assets. On the other hand, a digitization policy may have side effects (e.g., change management) or unintended consequences (e.g., negative effect on productivity) (Love & Matthews, 2019; Markus & Benjamin, 1997; Matthews et al., 2018).

Large-scale transport projects are complex adaptive systems and therefore mandating the use of digital technologies may have counter-intuitive outcomes. For example, contractors may ignore to bid for a project, even though the benefits of engaging with BIM are widely known, as they may not have the requisite skills, knowledge and experience to deliver a digital outcome. Thus, if governments are to create a procurement policy-making pathway to mandate the requirement for digital modelling in their large-scale transport projects, then they must follow the example set by the UK. Accordingly, governments need to 'work with' the construction industry to prepare it to engage and enact the transformational change needed to reap the benefits of moving from an analogue to a digital environment.

3.3. Delivery

It is widely accepted that there is no one best procurement method to deliver constructed assets (Skitmore & Marsden, 1988; Masterman, 2005; Naoum & Egbu, 2016). Each Australian State Government has developed their own guidelines and processes for selecting a procurement method to deliver an infrastructure asset (Farshid et al., 2017). 'National Guidelines for Infrastructure Delivery' (see https://www.infrastructure.gov.au/infrastructure/ngpd/index.aspx) have also been developed to inform the development of policy for individual states and promote cross-government consistency and 'best practices' for traditional and alliance contracting and Public Private Partnerships (PPPs). More specifically, the Australian Transport Planning Guidelines (see https://www.atap.gov.au/) have been developed to serve as a national standard for the planning, development and appraisal of transport infrastructure assets. However, prevailing procurement method selection processes and criteria are unable to cater for large-scale transport projects where emphasis needs to be placed on sharing risks, rewarding collaboration and innovation, and building a performance culture that is conducive to learning. Accordingly, "a collective environment centred on shared leadership, value creation and risks are needed to transition to a new procurement paradigm that goes beyond producing economic benefits but also includes those of a social and environmental nature" (Love et al., 2020, p. 9).

The delivery of large-scale transport projects requires governments to shift their mindsets from a position where a contract foresees a single result – "the value of a future outcome in exchange for money" (Construction Industry Council, 2014, p.23) to one where collaborative multi-party contract creates common objectives and shares the value that is generated. To this end, governments and their contractors/consortiums should work 'with' each other in unison to ensure positive outcomes are achieved by both parties.

There is a danger that governments may react to calls for the adoption of collaborative procurement methods (e.g., Design and Construct (D&C) by implementing them in a piecemeal manner. In this instance, no consideration is given to how an asset will be maintained and operated (i.e., ignoring the concept of 'thinking of end at the beginning'). Moreover, governments have exploited traditional collaborative procurement methods such as D&C by introducing a guaranteed maximum price mechanism into contracts. Here, financial incentives are determined by the percentage of cost savings that can be obtained below a project's contract value.

Contrastingly, if we are to consider the behavioural model presented in Table 1, economic rewards are provided to those parties that "integrate collaboratively, create knowledge and contribute to a positive organizational culture (Construction Industry Council, 2014, p.21). The shift from reactive collaborative procurement to proactive integration needs to be underpinned by authentic leadership, rewarding behaviour, equitable work arrangements, fairer payment mechanisms and knowledge creation (Construction Industry Council, 2014; ACA, 2017).\

3.3.1. From reactive collaborative procurement to proactive integration

Some State Governments, such the Victorian, have recognized the need for embracing alliance contracting to deliver its large-scale transport infrastructure projects. For example, the LXR Project in Melbourne, one of the largest rail infrastructure projects in the state's history, is being delivered through alliancing. Fundamentally, alliancing is a form of relationship contracting characterized by a culture of cooperation and collaboration between parties delivering a project (Holt et al., 2000; Walker & Lloyd-Walker, 2016).

Typically, in an alliance, contract risks are shared by way of incentives offered by the owner for how well the project is delivered as measured against agreed objectives. Three basic principles underpin the mechanics of alliancing: (1) a project is delivered by a single integrated team; (2) a joint governance framework is established; and (3) decisions are made on a 'best-for-project' basis with a no-blame culture in place. Alliances are traditionally used when flexibility and innovation are required to address the challenges that arise during a project's delivery.

While alliances have been proven to be successful forms of delivery, several Australian State Governments show some degree of trepidation as to whether they can provide taxpayers with value for money. A report by the New South Wales Auditor General (2003), for example, raised concerns about the Northside Storage Tunnel project in Sydney's ability to provide value for money. The issue of value for money has been the "Achilles Heel" of alliance contracting and has limited its broad acceptance as a delivery strategy to provide commercial benefits (MacDonald, 2011: p. iv).

The Australian Government have "acknowledged that there is an 'infrastructure deficit' and they recognize the need to facilitate private investment" (Cornwell et al., 2015, p. 6). While we expect governments to provide us with airports, roads, rails, ports and the like, they are often faced with an inability to fund projects. By leveraging on the private sector as a partner, governments can position themselves to deliver their infrastructure at a lower cost to taxpayers. Thus, a key motivation for governments considering PPPs is the possibility of bringing in new sources of financing for funding public infrastructure and service needs. That said, the PPP model or variant thereof can be used to overcome the ambiguity that resides around the issue of value for money. The use of PPP can reduce pressure on public budgets, allocate and share risks, free-up capacity and resources, take into account whole-lifecycle-costs, and engender innovation. Notably, for transport projects, PPPs are only suitable where the revenue stream takes the form of (PwC, 2017):

1. Charges paid by users, for example toll roads (i.e., user-charge PPP); and
2. A service payment from government; for example, this type was used to deliver the Sydney Metro-Northwest Project (i.e., service-payment PPP).

After all, there needs to be an incentive for the private sector to make a profit. So, in the case of the LXR project, a PPP would not have been suitable as there is no direct revenue stream that can be obtained from the asset. Both the 'user-charge' and 'service-payment' types PPP we have identified share common features and hybrids and other variants have been used to deliver large-scale transport projects in Australia (PWC, 2017).

The rationale for using PPPs has often been attributed to them providing a means of delivering the infrastructure that governments cannot afford to procure, rather than being a mechanism for achieving value for money and future-proofing their assets (Regan et al., 2013; PwC, 2017). We acknowledge that PPPs are not suitable for all projects, particularly regional roads in Australia. Though, to combat congestion, particularly in metropolitan areas, toll roads should be considered and therefore PPPs, notwithstanding a proclivity for taxpayers to deride them. It has been shown that the use of PPPs in large-scale toll road projects has been either a success or a failure (e.g., Regan et al., 2017). Irrespective of project performance, empirical research, however, has demonstrated that PPPs outperform traditional procurements methods in their ability to deliver assets within a project's cost and time requirements (Raisbeck et al., 2010).

Acknowledging that alliances are a mechanism that can motivate collaborative behaviours and that PPPs can provide value for money, then the logical conclusion is that they should be used together. Affirming this position, Clifton and Duffield (2006) have suggested that the concepts embedded with an alliance can be incorporated into a PPP contract structure. The integration of these concepts offers a "flexible structure for the management of change" and a "mechanism for managing long-term outcomes whilst maintaining the original commercial intent" (Clifton & Duffield, 2006, p.582). As these authors point out at the time of their study, the "finance market is currently unwilling to accept the risk profile of a full alliance regime" (p.582).

The 'hands-on' approach of alliances, where the client "actively engages with and collaborates directly with the project design and delivery from the outset of the project tender" provides flexibility to change (Walker & Jacobsson, 2014, p. 651). Contrastingly, PPPs are inflexible to change as clients are 'locked-in' to a long concession period. As a result, any "changes in context, technology through innovation, or cyclical changes in demographics" may leave the client with a low-value asset when it is returned after the concession period" (Walker & Jacobsson, 2014, p. 653).

For this reason, as well as to ensure an asset is future-proofed, we are advocating that a policy-making pathway should specify that alliance principles are integrated with a PPP contract to orchestrate a project-based environment that is adaptive and responsive to uncertainties. To the authors' knowledge, there has only been one PPP in Australia that has incorporated alliance, the $4.8 billion Brisbane Airport Link in Queensland (Jacobsson & Walker, 2013; Walker & Jacobsson, 2014). Of note, the project was a financial disaster. The project's consortium went into receivership, and the Airport Link roadway was sold for $2 billion (Letts, 2015). We need to point out here that the project was plagued with controversy from its outset as a consequence of its financial engineering and manufacturing yield. The project's financial structure has been described as being akin to being a 'dead parrot model' due to raising equity from private investors debt and planning to pay investors from capital (West, 2008). Notwithstanding such a controversy, the integration of alliance principles within the PPP structure was considered to be a success (Jacobsson & Walker, 2013; Walker & Jacobsson, 2014).

3.3.2. *To bundle or not unbundle, that is the question*

The issue of bundling versus unbundling of PPP contracts has been the subject of widespread debate in transport projects, particularly in the case of rail projects (Carpintero & Petersen, 2015; Chang, 2013; Hart, 2003; Hodge & Greve, 2007; Phang, 2007; Pulido et al., 2018). A bundled project is implemented on the basis of one PPP agreement with a single private sector partner (Pulido et al. 2018). In the case of a rail PPP, for example, the private sector partner generally assumes responsibility for construction of civil infrastructure, mechanical and electrical work, procurement of rolling stock, and operation of the system (Pulido et al. 2018).

Examples of bundled forms of PPP include Build Operate Transfer (BOT), Build Own Operate Transfer (BOOT), and Design Build Finance Operate/Maintain (DBFO/M). Such PPP models enable governments to be able to take advantage of "technologies that control operational costs (e.g., intelligent transportation systems)" (Buso, 2019, p. 3). Furthermore, the early involvement of contractors in the project's life-cycle provides governments with the ability to exploit their "stronger market/sector knowledge and expertise" and provide innovative solutions that can be used to future-proof assets (Buso, 2019, p. 3). Bundled contracts provide governments with cost certainty as the Special Purpose Vehicle (SPV) created to deliver the asset assumes all the responsibilities and risks associated with the project and is provided with an incentive to minimize costs over the assets life-cycle (Phang, 2007). Drawing on the experience of Beijing's Line 4 PPP project, Chang (2013) estimated that the public sector saved 9.4% of total CAPEX and OPEX when a bundled contract was used.

Despite the cost savings that can materialize from employing bundled contracts, we need to bring to the fore that their use to deliver Urban Rail Transit (URT) systems (e.g., heavy and light rail) has been somewhat marred by cost overruns. For example, the Vancouver's (Canada) rapid transit line CAPEX experienced a 22% cost increase (Siemiatycki, 2006). When organizations have differing goals and objectives, then opportunistic behaviours manifest within PPPs. Such opportunistic behaviour was observed by Carpintero and Petersen (2015) when a SPV's equities were controlled by a construction company as part of a bundled contract, it tended to place emphasis on opting to acquire short-terms benefits rather than considering whole-life cycle costs.

An unbundled approach splits various aspects of a project into a series of separate contracts (e.g., PPP agreement). In the case of a rail project, for example, separate contracts may be used for: (1) construction of civil works, (2) electromechanical equipment, (3) procurement of rolling stock, and (4) O&M of the system (Pulido et al., 2018). Such an approach provides government with the flexibility to replace contractors and adapt and respond to changing conditions (Pulido et al., 2018). Advocates for unbundling contracts suggest the following benefits can be derived (Solino & Vassallo, 2009; Cruz et al., 2015): (1) increased competition during the bidding process; (2) reduction in financial risks; (3) guaranteed integrity of service operation; and (4) a reduction OPEX.

There is an absence of definitive criteria for choosing between a bundled or unbundled contract. The upshot in this instance is that policy-makers are still left with a quandary, whether 'to bundle or unbundle'. Hart (2003) has suggested, however, that when the quality of construction but not operations can be specified, then an unbundled contract should be deployed as cost efficiencies can be obtained in comparison to the use of bundling. In the case of a URTs, for example, we need to consider not only construction and operations but also the property development that surrounds stations where quality is difficult to define and specify.

With the need to future-proof transport assets, there is a requirement for improved management of information so that decision-making during operations and maintenance can be ameliorated (Love et al., 2017). If unbundled contracting is used, then the flow of information from design to operations and maintenance can become fragmented and highly differentiated, requiring additional resources to manage the interfaces that exist within projects' life-cycle.

To take advantage of the benefits of disruptive technologies, particularly BIM, we suggest that governments use a 'bundled' PPP so that a seamless flow of information throughout the asset's life-cycle can be created. Thus, information transparency is ensued. Moreover, accountability solely lies with the SPV entity for ensuring the asset if future proofed. Having information structured following a standardized format from a project's onset provides the ability to undertake life-cycle performance measurement in real-time, and therefore an asset's resilience is monitored and managed (Love et al., 2015; Liu et al.; 2019).

3.4. Finance

There are two aspects to the finance enabling function that we believe governments need to bear in mind, while creating a policy-making procurement pathway for their transport assets: (1) its source; and (2) the contract and insurances. Naturally, an array of macro-and-micro economic factors will dictate the availability of finance for PPP projects as they require equity, debt and structured instruments such as bonds. Governments are well-educated in the array of finance mechanisms that can be used to deliver their PPP projects. For example, Australian Commonwealth and State Governments responded quickly to changeing market conditions by amending their PPP policies to "provide viability gap financing through up-front capital contributions, subsidies, reduced bid costs and simplified bid selection criteria" (Regan et al., 2017, p. 274).

Our intention here is not to suggest that one approach is more appropriate than another but rather provide an overview of PPP financing for large-scale transport projects in Australia. Then, we suggest alternative pathways for consideration in light of prevailing market conditions, particularly for rail projects. After all, if economic conditions are not suitable for a PPP, then an alternative delivery approach will be required, though the ability to effectively future-proof an asset may be abated.

3.4.1. Sources of finance/funding

After the Global Financial Crisis (GFC), there was a loss in confidence in capital markets and, loan finance became the principal source of debt, though the domestic bond market remained a source of finance for brownfield projects and refinancing (Infrastructure Australia, 2014). In 2013, the private sector contributed 55% of infrastructure investment in Australia, a significant increase over the 32% contribution in the early 1990s (Productivity Commission, 2014).

Private finance for large-scale transport projects generally takes the form of bank loans and bonds (Regan et al., 2011, 2017; Cornwell et al., 2015). Finance for large-scale transport investment possesses several distinctive properties (Regan et al., 2017, p. 268): (1) it is syndicated over a number of lenders; (2) security is of limited recourse; and (3) taken only in respect of the assets being financed, and debt servicing is matched to the anticipated cash flows of the project. Transport assets are generally capital-intensive, highly leveraged, and lending is, therefore syndicated to disperse risk (Yescombe, 2013). While each transaction is different, the principle of project finance is to match cash flows to debt servicing obligations based on revenue forecasts over 20 or more years (Regan et al., 2011, 2017).

Bank loans for infrastructure in Australia possess many of the characteristics of conventional project finance (Regan et al., 2017). A point of difference, as noted by Regan et al. (2017), however, has been "the tenor of Australian bank loans, which are generally one to five years" (p.268). While concessionaires have been able to adjust to short-term bank loans for long-term contracts (Infrastructure Australia, 2014), short-term lending reflected the short-term financing of Australian banks and created refinancing risk for borrowers and exposure to future interest rate volatility. Traditional project finance was difficult to obtain for PPPs in the aftermath of the GFC. The appointment of administrators to three toll road companies financed before 2008, the Lane Cove Tunnel in Sydney, and the Clem 7 and Airport Link projects in Queensland dented lender confidence in the toll road market (Regan et al., 2017).

As a result of the Australian Commonwealth and State Governments continued significant capital investment in infrastructure, especially in transport and the drive for asset recycling, projects are being underpinned by a sophisticated and well-tested project finance market (Cornwell et al., 2015; Regan et al., 2017). A substantial amount of government investment, for example, was provided to the $3.7 billion North West Rail PPP. Here, the New South Wales government contributed monthly payments during the delivery phase that totalled 50% of the total construction costs (Cornwell et al., 2015).

Australia has a relatively immature domestic bond market, which has constrained debt capital markets financing, and, as a result, this has subjected projects to higher refinancing risk (Cornwell et al., 2015). By and large, bank loan tenors' range between one and five years, and this period may be extended in limited circumstances. However, longer tenors are priced to reflect the regulatory factors and asset and liability management by banks that drive shorter tenors. There is, however, a general aversion to acceptance of patronage risk in light of the large-scale greenfield transport projects that have failed dramatically over the last decade, particularly in the toll roads sector (Cornwell et al., 2015; Regan et al., 2017).

So, from a policy perspective and in light of the experiences with large-scale toll roads governments, it needs to be recognized that the wholesale state allocation of demand risk to private bidders is no longer a sustainable option (Regan et al., 2017). Even though the bond market is immature, bonds were used to fund PPPs prior to the GFC to meet the investment risk appetite of foreign and domestic investors. Developments in infrastructure finance suggest that State participation in debt syndications, the issue of long-term infrastructure bonds, full or partial guarantees of project specific bonds are possible options to consider. For toll roads, for example, forecasting error of usage is a major weakness (e.g., Clem 7) and a "radical reappraisal of the science or future policy changes to share or mitigate demand risk is needed" (Regan et al., 2017, p. 274). Thus, these transactional experiences should inform policy development.

Irrespective of the financial model used, PPPs used for URT are prone to experiencing lower than expected operating revenue and being given subsidies (Li & Love, 2020). An alternative finance paradigm referred to as Land Value Capture has been identified as an appropriate mechanism to effectively address these shortfalls (Bray & Sayeg, 2013; Sharma & Newman, 2018). The combination of LVC with high fare recovery ratios, for example, have been found to significantly contribute to the successful development and operation of the Mass Transit Railway (MTR) in Hong Kong (Chang & Phang, 2017). Furthermore, Luan *et al.* (2014) have suggested that the experiences the URT that utilizes LVC in Shenzhen (China) have shown that a dependency on farebox revenue can be reduced from property sales and/or rental income. With increases in population and urban density, LVC is becoming a viable option for governments to consider as part of its mix for finance options.

3.4.2. Contracts and insurances

The mandating of BIM and the use of disruptive technologies in conjunction with alliance behaviours within a PPP environment will result in the stereotypical relationships that exist between disciplines being challenged. As a result, genuine collaborative relationships will be fostered. A 'bundled' PPP contract will facilitate the creation of a vertical supply chain, reduce project complexity and provide an environment to leverage the benefits of digital technology.

Blockchain is one particular technology that will significantly disrupt the traditional process used to procure and administer contracts for governments and SPVs. In simple terms, a blockchain is a decentralized database that chronologically and securely records transactions (e.g., financial and the transfer of value). Value in this instance may be a service, product, or an approval that emanates from a smart contract. The potential use of blockchains includes: (1) recording value exchanges; (2) administering smart contracts; and (3) the certification of a proof of existence (e.g., Digital Identification). A blockchain enables smart contracts to align with BIM, as the focus is on ensuring the transparency of information between parties. If this information is distributed to all parties in a way that guarantees neutrality, then an authentic ecosystem of certification, business rule execution and contracts can be shared through a model. In order to support this new way of collaborative working, governments should focus on developing new forms of contract and insurances (e.g., issues associated with intellectual property and warranties). New policy-making pathways therefore need to be developed in the future.

4. Conclusion

There is an urgent need for governments worldwide in general and the Australian Commonwealth and State Governments in particular to respond to the economic, environmental and social challenges that are adversely impacting their citizens. While there is a commitment by governments to invest in large-transport infrastructure, *inter alia*, uncertainty including when it is political threatens the ability to deliver new assets. The instability in government policy has resulted in projects being delayed or cancelled, which has contributed to high bid costs. A case in point is the cancellation of Victoria's contracted $6.8 billion East-West Link tollway project following a change of state government. Similarly, a change in government in Western Australia resulted in the $1.9 billion Perth Freight Link being cancelled after civil works had commenced.

Putting aside this unsteadiness, the traditional model that has been used to procure large-scale transport projects appears broken. There is an exigent demand to ensure projects are not only delivered in accordance with pre-defined objectives but also future-proofed. Accordingly, we suggest moving away from a prevailing "understand, reduce, respond" to a more adequate "understand, embrace, adapt" attitude towards complexity and uncertainty in the procurement of projects. The corollary is for governments to develop a coalesced policy-making pathway specifically for delivering their large-scale transport projects. In response to this call, we have built upon and extended the four enabling functions that we believe require attention by governments should they embark on a journey of creating such a particular policy-making pathway. Firstly, there is a need to ensure that intelligent assets and systems that are designed and specified respond to asset data. In this instance, asset managers will plays an integral role in the design process and ensure that data is structured and standardized to ensure connectivity between 'users' and 'systems' during operations and maintenance. Secondly, there is a need for Australia, like many other countries, to mandate the use of BIM so that processes can be digitally integrated and data and AI can be effectively used to improve decision-making. Thirdly, there needs to be a shift from reactive collaboration to proactive integration, whereby financial incentives are provided to organizations that engage in a learning culture. The fourth and final aspect we considered was financing. Here, the emphasis was placed on selecting its source based on transactional evidence and developing new forms of contract and insurance as a result of engaging in new ways of doing work.

The goal of this paper is not to present a prescriptive solution for procuring large-scale transport projects. Instead, we have tried to identify core problem areas and provide a pathway to develop a policy for procuring large-scale transports assets in a way such that their value can be realized. We have not presented any empirical research but have tried to draw from previous studies and real-life examples to demonstrate that our proposed enabling strategies have merit.

CRediT authorship contribution statement

Peter E.D. Love: Conceptualization, Writing – review & editing, Writing – original draft. **Lavagnon A. Ika:** Writing – review & editing, Writing – original draft. **Jane Matthews:** Writing – review & editing, Writing – original draft. **Xinjian Li:** Writing – review & editing, Writing – original draft. **Weili Fang:** Writing – review & editing, Writing – original draft.

Acknowledgments

The authors would like to acknowledge the financial support provided by the Australian Research Council (DP160102882).

References

Alwash, A., Love, P. E. D., & Olatunji, O. (2017). Impact and remedy of legal uncertainties in building information modelling. *ASCE Journal Legal Affairs and Dispute Resolution in Engineering and Construction (ASCE)LA.1943-4170*, Article 0000219.

Australian Constructors Association. (2017). Changing the game: How Australia can achieve success in the new world of megaprojects. Available at: https://www.constructors.com.au/wp-content/uploads/2015/11/Changing-the-Game-Mega-Projects-Final1.pdf Accessed 14th June 2019.

Banwell Report. (1964). *The placing and management of contracts for building and civil engineering work*. London, UK: HMSO.

Björk, B.-C., & Laakso, M. (2010). CAD standardisation in the construction industry - a process view. *Automation in Construction, 19*(4), 398–406.

Bowditch, G. (2013). *Australia's infrastructure cost conundrum*, 23rd October 2013. The Conversation. Available at: http://theconversation.com/australias-infrastructure-cost-conundrum-19037 Accessed 3rd October 2019.

Bray, D. J., & Sayeg, P. (2013). Private sector involvement in urban rail: Experience and lessons from South East Asia. *Research in Transportation Economics, 39*, 191–201.

Bray, D. J., Taylor, M. A. P., & Scrafton, D. (2011). Transport policy in Australia—evolution, learning and policy transfer. *Transport Policy, 18*(3), 522–532.

Bushell-Embling, D. (2018). *Qld to mandate BIM on major infra projects*. Bisci South Pacific News, 30th November, Available at: https://www.govtechreview.com.au/content/gov-geospatial/news/qld-to-mandate-bim-on-major-infra-projects-463322691 Accessed 27th November 2019.

Buso, M. (2019). Bundling versus unbundling: Asymmetric information on information externalities. *Journal of Economics, 28*(1), 1–25.

Carpintero, S., & Petersen, O. H. (2015). Bundling and unbundling in public-private partnerships: Implications for risk sharing in urban transport projects. *Project Management Journal, 46*, 35–46.

Catalão, F., Cruz, C. O., & Sarmento, J. M. (2019). The determinants of cost deviations and overruns in transport projects, an endogenous models approach. *Transport Policy, 74*, 224–238.

Cavalieri, M., Cristaudo, R., & Guccio, C. (2019). On the magnitude of cost overruns through the project life-cycle: An assessment for the Italian transport infrastructure projects. *Transport Policy, 79*, 21–36.

Chang, Z. (2013). Public-private partnerships in China: A case of the beijing No.4 Metro line. *Transport Policy, 30*, 153–160.

Chang, Z., & Phang, S. Y. (2017). *Urban rail transit PPPs: Lessons from East asian cities. 105* pp. 106–122). Transportation Research Part a-Policy and Practice.

Clifton, C., & Duffield, C. F. (2006). Improved PFI/PPP service outcomes through Alliance principles. *International Journal of Project Management, 24*, 573–586.

Commonwealth of Australia. (1991). *Construction costs of major projects*, 11th March, Report No.8. Canberra, Australia: Australian Commonwealth Publishing Service. Available at: https://www.pc.gov.au/inquiries/completed/major-construction-costs/08projects.pdf Accessed 29th November 2019.

Commonwealth of Australia. (2019). *Building our future: Delivering the right infrastructure*. Canberra, ACT: Department of Infrastructure, Regional Development and Cities, Commonwealth of Australia. Available at: https://investment.infrastructure.gov.au/files/budget-2019-20/Building-Our-Future-Delivering-the-Right-Infrastructure-for-a-Growing-Nation-2019.pdf Accessed 8th September 2019.

Construct 21. (2000). *Construct 21. Ministry of manpower and ministry of national development*. Singapore https://www.nas.gov.sg/archivesonline/data/pdfdoc/1999102001.htm Accessed 27th January 2021.

Construction Industry Council. (2014). *Built environment 2050: A Report on our digital future. Bim 2050*. Available at: be2050-cicbim2050-2014-1.pdf. Accessed 1st December 2019.

Cornwell, P., Gordon, R., & Farnsworth, B. (2015). *Project finance in Australia. GTDT: Market intelligence – project finance*. Available at: https://www.allens.com.au/insights-news/insights/2015/03/paper-project-finance-in-australia/ Accessed 5th December 2019.

Coultan, M. (2016). *Cost overruns 'the new normal' in transport projects*. The Australian, 1st December, Available at: https://www.theaustralian.com.au/nation/politics/cost-overruns-the-new-normal-in-transport-projects/news-story/b73a56a972e8b052d0d2ed2b72b50280 Accessed 7th October 2017.

Council on Foreign Relations. (2016). *Road to nowhere: Failing U.S transportation infrastructure, renewing America – progress report and scorecard, january, Council on foreign relations*. New York. Available https://cfrd8-files.cfr.org/sites/default/files/book_pdf/RA-RoadNowhere.pdf Accessed 8th September 2019.

Cruz, C. O., Marques, R. C., & Pereira, I. (2015). Alternative contractual arrangements for urban light rail systems: Lessons from two case studies. *ASCE Journal of Construction Engineering and Management, 141*, Article 0000942 (ASCE)CO.1943-7862.

Davies, A. (2014). *Why is infrastructure so bloody expensive? Crikey*, 16th February 2014. Available at: https://blogs.crikey.com.au/theurbanist/2012/02/16/why-is-infrastructure-so-bloody-expensive/ Accessed 3rd October 2019.

Egan, S. J. (1998). *Rethinking construction. Construction task force report*. London, UK: Department of Environment, Transport and Regions. Available at: https://constructingexcellence.org.uk/wp-content/uploads/2014/10/rethinking_construction_report.pdf Accessed 27th January 2021.

Evans, N. (2016). *ASIC probes suspected insider trading linked to Forrestfield airport rail link*. The West Australian, 6th April, Available at: https://thewest.com.au/news/wa/asic-probes-suspected-insider-trading-linked-to-forrestfield-airport-rail-link-ng-ya-103200.

Flint, J. (2019). *Damning documents reveal Forrestfield Airport Link tunnel workers at risk from repeated safety breaches*. PerthNow, 3rd February https://www.perthnow.com.au/news/transport/damning-documents-reveal-forrestfield-airport-link-tunnel-workers-at-risk-from-repeated-safety-breaches-ng-b881090970z Accessed 7th October 2019.

Gallaher, M. P., O'Connor Dettbarn, J. L., & Gilday, L. T. (2004). *Cost analysis of inadequate interoperability in the US capital facilities industry*. Gaithersburg, MD: US Department of Commerce Technology Administration, National Institute of Standards and Technology.

Gibb, A., & Isack, F. (2001). Client drivers for construction projects: Implications for standardization. *Engineering Construction and Architectural Management, 8*(1), 46–58.

Gil, N., & Pinto, J. K. (2018). Polycentric organizing and performance: A contingency model and evidence from megaproject planning in the UK. *Research Policy, 47*, 717–734.

Global Railway Review. (2020). *Trump administration to invest $1bn in revitalising America's transport infrastructure. Global Railway Review*, 16th September 2020, Available at: https://www.globalrailwayreview.com/news/109174/trump-administration-invest-america-transport-infrastructure/ Accessed 27th January 2020.

Goulden, M., Ryley, T., & Dingwall, R. (2014). Beyond 'predict and provide': UK transport, the growth paradigm and climate change. *Transport Policy, 32*, 139–147.

Government of Canada. (2017). Budget 2017: Building a strong middle class. Available at: https://www.budget.gc.ca/2017/docs/themes/infrastructure-en.html Accessed 27th January 2021.

Hart, O. (2003). Incomplete contracts and public ownership: Remarks and an application to public–private partnerships. *Economic Journal, 113*, C69–C76.

Hirschman, A. O. (1967). *Development projects observed*. Washington DC: The Brookings Institution.

Hodge, G. A., & Greve, C. (2007). Public–private partnerships: An international performance review. *Public Administration Review, 67*(3), 545–558.

Holt, G. D., Love, P. E. D., & Li, H. (2000). The learning organisation: A paradigm for mutually beneficial strategic construction alliances. *International Journal of Project Management, 18*(6), 415–423.

Infrastructure, & Projects Authority.. (2020). *Analysis of the national Infrastructure and construction procurement pipeline 2020/21. A report to cabinet and hm treasury*. June 2020, Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/892451/CCS118_CCS0620674232-001_Pipeline_document_2020_WEB.pdf Accessed 27th January 2021.

Infrastructure Australia. (2014). *Review of infrastructure debt capital market financing*. February, Infrastructure Australia Available at: https://www.infrastructureaustralia.gov.au/sites/default/files/2019-06/review_of_infrastructure_debt_capital_market_financing_2014_03_28.pdf Accessed 4th December 2019.

Infrastructure Australia. (2019). *An assessment of Australia's infrastructure needs: The Australian infrastructure audit 2019*. June, Infrastructure Australia Available at: https://www.infrastructureaustralia.gov.au/publications/australian-infrastructure-audit-2019 Accessed 8th September 2019.

International Organization for Standardization (ISO). (2014). *International standard IS0-55000, asset management – overview, principles and terminology 2014* (p. 25). Available at: https://www.iso.org/standard/55088.html.

Jacobsson, M., & Walker, D. H. T. (2013). Alliancing within a public-private partnership. *Proceedings of 22nd nordic academy of management conference*. University of Iceland, 21st-23rd August, Reykjavik, Iceland.

Kommerskollegium. (1996). *Byggesktorn – Spelregler for ökad konkurrens* (building sector – rules for increased competition), konkurrensverket, NUTEK, stockholm, Sweden. Available at: http://www.konkurrensverket.se/globalassets/publikationer/rapporter/byggsektorn–spelregler-for-okad-konkurrens.pdf Accessed 27th January 2021.

KTM. (1996). *Laatu rakentamisen menestrystekijäksi (quality as a success factor in construction, KTM työryhma ja roimikuntaraportteja*. Helsinki: Finland.

Kuspura, A. (2018). *Engineering construction on infrastructure: 10 years of trends*. Engineers Australia Available at: https://www.engineersaustralia.org.au Accessed 8th September 2019.

Laakso, M., & Kiviniemi, A. O. (2012). The IFC standard: A review of history, development, and standardization, information technology. *Journal of Information Technology in Construction, 17*(9), 134–161.

Latham, M. (1994). *Constructing the team: Joint review of procurement and contractual arrangements in the UK construction industry*. UK: Department of the Environment.

Letts, S. (2015). *Brisbane's troubled Airportlink sold for $2.8 billion less than construction cost*. ABC News, 24th November, Available at: https://www.abc.net.au/news/2015-11-24/brisbanes-troubled-airportlink-sold-at-almost-60pc-loss/6968586 Accessed 1st December 2019.

Li, X., & Love, P. E. D. (2020). *Employing land value capture in urban rail transit public private partnerships: A retrospective analysis of Delhi's airport express line. Research in transportation Business and management* (in press).

Lima, E. S., & Costa, A. P. C. S. (2019). Improving asset management under a regulatory view. *Reliability Engineering & System Safety, 19*, 106523.

Liu, J., Love, P. E. D., Sing, C.-P., & Niu, B. (2019). Life-Cycle performance of transport infrastructure assets: Implications for policy. *Transportation Research D: Transport and Environment, 77*, 615–626.

Love, P. E. D., Ahiaga-Dagbui, D., Welde, M., & Odeck, J. (2017). Cost performance light transit rail: Enablers of future-proofing. *Transportation Research: Policy and Practice, 100*, 27–39.

Love, P. E. D., Ika, L., Locatelli, G., & Ahiaga-Dagbui, D. D. (2018a). Future-proofing 'next generation' infrastructure assets. *Frontiers of Engineering Management, 5*(3), 407–410.

Love, P. E. D., Ika, L. A., Matthews, J., & Fang, W. (2020). Shared leadership, value and risks in large-scale transport projects: Re-calibrating procurement policy for post-COVID-19. *Research in Transportation Economics, 100999*. https://doi.org/10.1016/j.retrec.2020.100999

Love, P. E. D., Lui, J., Matthews, J., Sing, C. P., & Smith, J. (2015). Future-proofing PPPs: Performance measurement and building information modelling. *Automation in Construction, 56*, 26–35.

Love, P. E. D., & Matthews, J. (2019). The 'How' of benefits management for digital technology: From engineering to asset management. *Automation in Construction, 107*, 10293.

Love, P. E. D., Zhou, J., Matthews, J., Lavender, M., & Morse, T. (2018b). Managing rail infrastructure for a digital future: Future-proofing of asset information. *Transportation Research A Policy and Practice, 110*, 161–176.

Love, P. E. D., Zhou, J., Matthews, J., & Luo, H. (2016). System information modelling: Enabling digital asset management. *Advances in Engineering Software, 102*, 155–165.

Lyons, G., & Davidson, C. (2016). Guidance for transport planning and policymaking in the face of an uncertain future. *Transportation Research: Policy and Practice, 88*, 104–118.

MacDonald, C. (2011). *Value for money in project alliances*. Doctor of Philosophy (PhD), Property Construction and Project Management. Melbourne, Victoria, Australia: RMIT University.

Markus, L. M., & Benjamin, R. I. (1997). The magic bullet theory in IT-enabled transformation. *Sloan Management Review*, 55–68.

Masterman, J. W. E. (2005). *An introduction to building procurement systems* (2nd ed.). London, UK: E&F Spon.

Matthews, J., Love, P. E. D., Mewburn, J., & Stobaus, C. (2018). Building information modelling in 'practice': Views from a collaboration and change management perspective during construction. *Production Planning & Control, 29*(3), 202–219.

Maylor, H., & Turner, N. (2017). Understand, reduce, respond: Project complexity management theory and practice. *International Journal of Operations & Production Management, 37*(8), 1076–1093.

McGraw-Hill Construction. (2012). *The business Value of BIM for infrastructure: Addressing America's infrastructure Challenges with Collaboration and technology. Design and construction SmartMarket report, research and analytics bedford*. MA. Available at: https://images.autodesk.com/adsk/files/business_value_of_bim_for_infrastructure_smartmarket_report__2012.pdf Accessed 19th November 2019.

Mills, J., Shilson, S., Woodley, Q., & Woodwark, A. (2011). *Keep Britain moving: The United Kingdom's transport infrastructure needs*. McKinsey & Company. Available at: https://www.mckinsey.com/~/media/McKinsey/dotcom/client_service/Infrastructure/PDFs/Keeping_Britain_Moving_the_United_Kingdoms_Transport_Infrastructure_Needs.ashx Accessed 8th September.

Moran, G., & Ha, J. (2019). *Transport promises for election 2019: The good, the bad and the downright ugly* Accessed 8th June 2019. The Conversation, 15th May, Available at: http://theconversation.com/transport-promises-for-election-2019-the-good-the-bad-and-the-downright-ugly-115138.

Moschouli, E., Soecipto, R. M., & Vanelslander, T. (2019). Cost performance of transport infrastructure projects before and after the global financial crisis (GFC): Are differences observed in the conditions of project performance? *Research in Transportation Economics, 75*, 21–35.

Naoum, S., & Egbu, C. (2016). Modern selection criteria for procurement methods in construction: A state-of-the-art literature review and a survey. *International Journal of Managing Projects in Business, 9*(2), 309–336.

New South Wales Auditor General. (2003). *NSW auditor general's report, performance audit, 'Sydney water corporation - Northside storage tunnel project*. Sydney, NSW, Australia: NSW Auditor General.

Niesche, C. (2019). *The biggest infrastructure projects right now*. The Australian Institute of Company Directors, 1st February 2019 https://aicd.companydirectors.com.au/membership/company-director-magazine/2019-back-editions/february/infrastructure Accessed 7th October 2019.

Odeck, J. (2004). Cost overruns in road construction – what are their size and determinants. *Transport Policy, 24*, 43–53.
O'Sullivan, M. (2018). *Experts warned on high costs of Sydney light Rail project six years ago*. The Sydney Morning Herald 13th September, Available at: https://www.smh.com.au/national/nsw/experts-warned-on-sydney-light-rail-project-six-years-ago-20180910-p502ty.html Accessed 13th June 2019.
Phang, S. Y. (2007). Urban rail transit PPPs: Survey and risk assessment of recent strategies. *Transport Policy, 14*(3), 214–231.
Price Waterhouse Coopers (Pwc). (2017). *Reimagining public private partnerships*. 17th october. Available at: https://www.pwc.com.au/legal/assets/reimagining-ppps-oct17.pdf Accessed 30th November.
Productivity Commission. (2014). Public infrastructure. *Productivity Commission Inquiry Report, 2*(71), 27th May, Commonwealth of Australia, Canberra, ACT. Available at: https://www.pc.gov.au/inquiries/completed/infrastructure/report Accessed 14th June 2019.
Pulido, D., Darido, G., Munoz-Raskin, R., & Moody, J. (2018). *The urban rail development handbook*. Washington DC, USA: The World Bank Accessed 15th November 2018. Available at: https://openknowledge.worldbank.org/handle/10986/30392.
Rahmani, F., Maqsood, T., & Khalfan, M. (2017). An overview of construction procurement methods in Australia. *Engineering Construction and Architectural Management, 24*(4), 593–609.
Raisbeck, P., Duffield, C., & Xu, M. (2010). Comparative performance of PPPs and traditional procurement in Australia. *Construction Management & Economics, 28*(4), 345–359.
Regan, M., Love, P. E. D., & Smith, J. (2013). Capital market conditions and public private partnerships in Australia. *ASCE Journal of Infrastructure Systems, 19*(3), 335–342.
Regan, M., Smith, J., & Love, P. E. D. (2011). Impact of the capital market collapse on public private partnership infrastructure projects. *ASCE Journal of Construction, Engineering and Management, 137*(1), 6–16.
Regan, M., Smith, J., & Love, P. E. D. (2017). Financing of public-private partnerships: Transactional evidence from Australian toll roads. *Case Studies on Transport Policy, 5*(2), 267–278.
Report, S. (1944). *The placing and management of building contracts*. London, UK: HMSO.
Roy, R., Low, M., & Waller, J. (2005). Documentation, standardization and improvement of the construction process in house building. *Construction Management & Economics, 23*(1), 57–67.
Sas, N. (2019). *NSW Government in 'negotiations' to settle court dispute with Sydney light rail contractor Acciona, says Premier*. ABC News, 31st January 2019, Available at: https://www.abc.net.au/news/2019-01-31/nsw-government-in-negotiations-with-sydney-light-rail-contractor/10765608 Accessed 2nd June 2019.
Sharma, R., & Newman, P. (2018). Can land value capture make PPP's competitive in fares? A Mumbai case study. *Transport Policy, 64*, 123–131.
Siemiatycki, M. (2006). Implications of private-public partnerships on the development of urban public transit infrastructure - the case of Vancouver, Canada. *Journal of Planning Education and Research, 26*, 137–151.
Skitmore, R. M., & Marsden, D. (1988). Which procurement system? Towards a universal procurement selection technique. *Construction Management & Economics, 6*(1), 71–89.
Solino, A. S., & Vassallo, J. M. (2009). Using public-private partnerships to expand subways: Madrid-Barajas international airport case study. *ASCE Journal of Management in Engineering, 25*, 21–28.
Sosoff, H. (2014). *Transportation infrastructure is the road to more competitive US Manufacturing*. Industry Week, 5th November Available at: https://www.industryweek.com/supply-chain/transportation/article/21963997/transportation-infrastructure-is-the-road-to-more-competitive-us-manufacturing Accessed 27th January 2021.
Teicholz, P. (2013). *BIM for facility managers*. Hoboken, NJ: Wiley and Sons.
Terill, M., & Danks, L. (2016). *Cost overruns in transportation projects*. Melbourne, Australia: Gratton Institute. Available at: https://grattan.edu.au/wp-content/uploads/2016/10/878-Cost-overruns-on-transport-infrastructure.pdf Accessed 8th September 2019.
Terrill, M. (2017). *Stuck in traffic? Road congestion in Sydney and Melbourne*. Melbourne, Australia: Gratton Institute. Available at: https://grattan.edu.au/wp-content/uploads/2017/10/892-Road-congestion.pdf Accessed 8th September 2019.
Terrill, M. (2019). *Tough decisions needed to cut congestion*. Melbourne Australia: Gratton Institute. Available at: https://grattan.edu.au/news/tough-decisions-needed-to-cut-congestion/ Accessed 8th September 2019.
Tolman, F. (1999). Product modelling standards for the building and construction industry: Past, present and future. *Automation in Construction, 8*, 227–235.
Tourish, D. (2019). *Management studies in Crisis: Fraud, deception and meaningless*. Cambridge, UK: Cambridge University Press.
Transport Canada. (2020). Government of Canada invests in transportation infrastructure at the port of Montreal to move goods to market. Transport Canada. 30th December. Available at: https://www.newswire.ca/news-releases/government-of-canada-invests-in-transportation-infrastructure-at-the-port-of-montreal-to-move-goods-to-market-827704642.html Accessed 27th January 2020.
TRB. (2019). *Critical Issues in transportation 2019: Policy snapshot*. Transportation research board. Available at: http://onlinepubs.trb.org/onlinepubs/policystudies/criticalissuesbrochure.pdf Accessed 27th January 2021.
Turró, M., & Penyalver, D. (2019). Hunting white elephants on the road. A practical procedure to detect harmful projects of transport infrastructure. *Research in Transportation Economics, 75*, 3–20.
Walker, D., & Jacobsson, M. (2014). A rationale for alliancing within a public-private partnership. *Engineering Construction and Architectural Management, 21*(6), 648–673.
Walker, D., & Lloyd-Walker, B. (2016). Understanding the motivation and context for alliancing in the Australian construction industry. *International Journal of Managing Projects in Business, 9*(1), 74–93.
West, M. (2008). *Macquarie's dead-parrot model*. The Sydney Morning Herald, 31st July, Available at: https://www.smh.com.au/business/macquaries-deadparrot-model-20080731-3nwt.html Accessed 2nd December 2019.
Wiggins, J. (2016). *Crossrail lessons timely for Australian rail projects*. Sydney Morning Herald, 28th March, Available at: https://www.smh.com.au/business/crossrail-lessons-timely-for-australian-rail-projects-20160322-gnompm.html Accessed 19th November 2019.
Wiggins, J., & Ludlow, M. (2018). *NSW overhauls mega projects amid cost blowouts*. Financial Review, 5th June 2018, Available at: https://www.afr.com/business/nsw-overhauls-mega-projects-amid-cost-blowouts-20180604-h10y6b Accessed 2nd June 2019.
Williams, T. A., Gruber, D. A., Sutcliffe, K. M., & Shepherd, D. A. (2017). Organizational response to adversity: Fusing crisis management and resilience research streams. *The Academy Of Management Annals, 11*(2), 733–769.
Wright, S., & Irvine, J. (2019). *Some seats are 'better' than others: Coalition sandbagging key electorates with taxpayer funds* Accessed 8th June 2019. The Age, 7th May, Available at: https://www.theage.com.au/federal-election-2019/some-seats-are-better-than-others-coalition-sandbagging-key-electorates-with-taxpayer-funds-20190501-p51j6b.html.
Yescombe, E. R. (2013). *Principles of project finance* (2nd ed.). San Diego, CA: Academic Press.