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Value for Money assessments for Public-Private Partnerships: characteristics, research directions, and policy implications

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ABSTRACT

Value for Money (V*f*M) has been used as a critical criterion for evaluating Public-Private Partnerships (PPPs), a popular procurement strategy for delivering infrastructure assets. However, there is a tendency for prevailing V*f*M techniques (e.g., Public Sector Comparator, PSC) to focus on obtaining cost savings rather than value *per se*. Despite the criticisms of the PSC and its alternatives for assessing V*f*M, there remains no research comparing decision-making methods for procuring transport infrastructure projects. In this instance, the upshot has been the public sector's inability to safeguard and deliver V*f*M to their taxpayers. Against this backdrop, we systematically review the V*f*M assessment literature to understand the effectiveness (e.g., strengths, weaknesses, opportunities, and threats) of prevailing approaches used to determine the 'value' of transport projects. In light of our review, we propose and introduce the concept of the 'onion' architecture to improve the decision-making practice of PPPs, which comprises four systematic future research directions and policy implications. To this end, our paper provides a platform for developing new procurement paradigms that can be used to future-proof infrastructure assets.

1. Introduction

Ensuring infrastructure is delivered using an appropriate procurement approach is critical for satisfying clients' expectations and ensuring project success (Love et al., 1998), especially when governments are subjected to fiscal constraints (Reeves, 2015; Penyalver et al., 2019). The budgets of most governments often do not include sufficient money to underwrite transport projects, particularly those of a large scale that may need to be delivered (Love et al., 2023a, 2023b). In cases where the public sector cannot fund a required and/or demanded transport asset, it may engage in Private Participation in Infrastructure (PPI) (e.g., Public-Private Partnerships, PPPs) to bring forward the project.

To determine the feasibility of a PPI and the procurement options (e.g., Build-Own-Operate-Transfer, Design-Build-Finance-Operate and PPPs) to be considered, they are compared with conventional forms (e.g., Alliancing or Design and Build) using a public sector comparator (PSC) to assess their ability to provide V*f*M (European Investment Bank – EIB, 2015). According to EIB (2015), V*f*M seeks to capture the relationship between cost (i.e., whole-life costs) and value (i.e., the quality and quantity of service or performance level over the project lifecycle). Notably, an ineffective assessment of V*f*M (e.g., lack of comparisons between PPPs and conventional procurement), as reported by Grubišić Šeba (2015), may result in project mis-performance.

Studies have indicated that prevailing V*f*M assessment techniques emphasise cost savings rather than assessing value *per se* (e.g., asset functionality) (Liu et al., 2018; Yescombe and Farquharson, 2018; Zhao et al., 2021). For example, Decorla-Souza and Farajian (2017) argued that social impacts should be considered in V*f*M assessment when selecting a PPP. Even in the case of a 'cost only' scenario, Grout (2005) showed that the price of the London Underground project showed limited V*f*M due to uncertain revenue prices and high transaction cost (i.e., around 1.5% of the 30-year deal price) (p.48). In another case where V*f*M was examined against public projects for 53 road PPPs in the United States (US), Petersen (2019) summarised that V*f*M was not significantly demonstrated in terms of efficiency. As such, the validity of PSC

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becomes questionable as it provides asymmetric comparisons between projects based on subjective assumptions (Reeves, 2013) and is overly reliant on contentious discount rates and inaccurate estimates (Bain, 2010; Zwalf et al., 2017).

Decorla-Souza et al. (2013) suggest that cost-benefit analysis (CBA) would be a far more comprehensive, robust and effective approach to determining V*f*M than the PSC. Yet Ackerman and Heinzerling (2002) are highly critical of CBA and consider it to be akin to "pricing the priceless" benefits (p.1553). What is more, Penyalver et al. (2019) contend that CBA cannot capture the intergenerational impacts of transport infrastructure in its V*f*M assessment. Thus, determining a suitable method to assess V*f*M for transport PPPs remains problematic for decision-makers.

According to the NAO (2018) and the United Kingdom (UK) UK Government (2018), there has been an inability of the public sector to safeguard and deliver V*f*M to taxpayers due to the ambiguity of prevailing tools used for its assessment. The UK is not alone here, as others such as Australia (Siddiquee, 2011), Canada (Siemiatycki and Farooqi, 2012), Hong Kong (HK) (Hayllar, 2010), South Africa (SA) (Fombad, 2014), and the US (Kweun et al., 2018), to name a few, are faced with a similar dilemma.

With an average worldwide investment of US$3.7 trillion on infrastructure (Global Infrastructure Hub - Oxford Economics, 2017) and shortages in finance due to the Coronavirus of 2019 (COVID-19) and the war in Ukraine, there is a greater need to deliver V*f*M. Reinforcing this point, the Global Infrastructure Hub (2021) maintains that "mobilising private capital is key to closing the infrastructure financing gap and has become even more critical as the COVID-19 pandemic has further limited the investment capacity of governments" (p.4).

A germane case is the launch of the Infrastructure Bank in the UK to harness private investment in infrastructure, including transport projects (HM Treasury, 2021). As the PPI forms need to be rationalised by V*f*M assessment, it becomes self-evident that understanding the inherent characteristics of existing techniques is essential for governments to choose one to appraise their approach to deliver a transport infrastructure asset. Thus, this leads us to propose the following research questions, which we aim to address in this paper using a systematic review: (1) What are the features of existing techniques in assessing V*f*M? and (2) What improvements can be made to ensure better V*f*M assessment of infrastructure projects?

We commence our paper by providing a contextual backdrop to the V*f*M research problem facing government agencies (Section 2). Next, we describe our research method used to conduct a systematic review of the literature, which is used to address our research questions (Section 3). Current V*f*M assessment techniques are identified, and their strengths, weaknesses, opportunities and threats (SWOT) are subsequently analysed (Section 4). The analysis enables us to propose future directions for research and policy (Section 5) before presenting the paper's conclusions (Section 6).

2. Setting the scene

There is no universally accepted definition of V*f*M due to the complexity of monetising 'value' (Barton et al., 2019). Under the auspices of *Value Theory*, value is represented by a specific price (money) within a market, which explains the emphasis placed on cost in V*f*M assessment (Milios, 2003). In contrast, value in the context of transport infrastructure projects is framed as providing the public with economic, social and environmental benefits (Department for Transport, 2017; Love et al., 2021).

Suffice to say, however, the fundamentals associated with V*f*M have been well-documented by the public sector, whereby terms such as 'economy', 'efficiency, and 'effectiveness' take centre stage (Glendinning, 1988; Shaoul, 2005; Jackson, 2012; Barton et al., 2019). Additionally, 'equity' is identified as another element of V*f*M, which is referred to as the "fair spend (of public money) to provide the public with the non-compromised quality of services" (NAO, 2011: p.1). Accordingly, V*f*M is defined as the "optimum combination of whole-of-life costs and quality (or fit for purpose) of the good or service to meet the users' requirement" (HM Treasury, 2006: p.7). In this case, V*f*M determines if a government has spent their money appropriately and achieved its expected outcomes (NAO, 2013).

Several studies have evaluated and critically reviewed the project outcomes of transport infrastructure using V*f*M (Kornai and Boskin, 1979; Morallos et al., 2009; Garrido et al., 2017; Wallis, 2020). Here, project appraisal comprises formative and summative assessments. A formative evaluation is initiated at the project's inception stage and used for decision-making (i.e., *ex-ante*). A summative evaluation examines actual outputs (i.e., *ex-post*) (Harlen and James, 2006).

In the context of transport project appraisal, Mackie and Preston (1998) identified 21 sources of error and bias, including unclear objectives and inconsistent criteria. Similarly, Douglas and Brooker (2013) reviewed the transport project appraisal in Australia from its tentative beginnings in the 1960s. The concept of transport-related project appraisal dates back to the early 19th century when the US Army Corps of Engineers managed its water projects. A typical case was a combined feasibility study of both the Upper Mississippi River and Illinois Waterway in 1993 to evaluate options for reducing waterway congestion (National Research Council, 2004), which can be considered a formative evaluation.

A V*f*M assessment of PPP appraisal is typically carried out during the project's inception stage. The public sector uses it as a decision-making tool in conjunction with the business case to select an appropriate procurement strategy (Grimsey and Lewis, 2005; Morallos and Amekudzi, 2008; Opara, 2018; Zhao et al., 2021). Hence, V*f*M is utilised as a specific form of project appraisal in this paper to evaluate the appropriate procurement approach (i.e., PPPs or conventional procurement) for transport infrastructure projects. As a result, the public sector used the three types of project appraisal to assess procurement options, namely financial feasibility analysis, PSC, and CBA, which were broadly treated as a type of V*f*M assessment in this paper (DeCorla-Souza, 2018). While CBA is typically employed as a 'go or no go' decision for projects, it has gradually been equated to V*f*M assessment in evaluating PPPs and conventional procurement (Grimsey and Lewis, 2005; de Faria Silva et al., 2022).

Typically, V*f*M is determined by comparing a project's lifecycle costs with the PSC (Siemiatycki and Farooqi, 2012). In this case, the PSC becomes the benchmark for calculating the Net Present Value (NPV) of a similar project procured using a conventional procurement form (Quiggin, 2008). As we mentioned above, however, the use of the PSC has been subjected to intense criticism, and alternatives such as CBA have also come under scrutiny. Despite the sporadic efforts that have addressed the critical success factors (Almarri and Boussabaine, 2017), risk transfer (Siemiatycki and Farooqi, 2012), and information exchange (Ren et al., 2019), we were unable to identify research articles that have collectively analysed the techniques available and their features to assess V*f*M. Although Petersen (2019) conducted a systematic review of PPPs and conventional public procurement, it focused mainly on PPPs' performance (i.e., cost, quality and V*f*M) rather than the existing V*f*M techniques that have rationalised using PPPs. Given the continuing importance of V*f*M in the realm of PPPs (Song et al., 2016; Cui et al., 2018), their features must be examined, and directions offered to guide future research and policy.

3. Systematic review

We systematically reviewed the literature to determine existing research approaches and current developments and generate new insights about V*f*M assessments. Such a review can provide transparency and clarify the state of existing research, enabling implications for research and policy to be formulated (Feak and Swales, 2009). According to Snyder (2019), a systematic review identifies evidence that

can be used to answer the pre-specified research question(s). Driven by the research questions stated above, we adapted Yi and Wang's (2013) and Li and Love's (2020) approach to undertaking a systematic review, which comprises three stages, as shown in Fig. 1.

3.1. Preparation-retrieval of target research

Stage 1 focussed on retrieving relevant research papers from the Web of Science (WoS) and Scopus databases. According to Bramer et al. (2017), using these databases is robust for generating optimal search results for a systematic review. A series of keywords, such as 'value for money assessment', 'value for money analysis', or 'value for money evaluation' and 'PPI', 'PPP', 'Private Finance Initiative' (PFI) The following query string was entered into the selected databases: [(value AND for AND money) OR (V*f*M) OR (value AND for AND money AND assessment*) AND (public AND private AND partnership*) OR (PPP)]. Keywords were inputted successively as 'topics' in the WoS for search whilst applied in the 'Title/Abstract/Keyword' (T/A/K) field of the Scopus.

In line with Feak and Swales (2009), this research applied the following criteria and filters to minimise bias: (1) timespan: 2000 to 2022 inclusive; (2) all types of articles (e.g., journal, review, conference proceedings, books and book chapters); and (3) Language: English. Subsequently, 358 relevant articles were identified, with the majority (i.e., 249) being scholarly journal articles (Fig. 2[1]). Notably, there was a marginal decline in the number of articles relating to V*f*M in the periods of 2010–2011 and 2014–2015, though there is no explicit explanation for this occurrence. Nevertheless, studies are soaring overall as worldwide, many transport PPPs have underperformed (Macário et al., 2015; Anago, 2022), delivering lower-than-expected V*f*M such as Brisbane's M7 Clem Jones Tunnel, Sydney Cross City Tunnels, and Delhi's Airport Metro Express, to name a few (Love et al., 2018; Li and Love, 2019). However, in the periods 2018–2019 and 2020–2021, we saw a decrease in the articles published, possibly due to research being hampered due to COVID-19 and governments questioning the costs of PPPs, such as the UK government who initiated a moratorium on their use in 2018.

3.2. Implementation-visual examination and identification

A visual examination was performed at Stage 2 to identify pertinent literature using keywords derived from the T/A/K analysis. The titles of the 358 results were compared to eliminate duplication. A total of 110 literature sources were discarded. Thus, 248 articles were identified for review. The abstracts and keywords were examined to develop a 'pool' specific to V*f*M assessment studies. As a result, 88 articles were clustered together. Furthermore, V*f*M assessment practices in different countries and their relevant references were scrutinised to ensure their relevance.

To illustrate the intellectual evolution of PPP V*f*M assessment within the selected articles, the algorithmic historiography was programmed using the HistCite software (Garfield et al., 2003). As Garfield et al. (2003) contend, performing historiography enables an understanding of how the basic concepts or perceptions of a paradigm (i.e., a model of a field) have changed by identifying significant works for a given topic and providing a graphic and genealogical presentation of the links between them. For example, in this paper, the algorithmic historiography was programmed to illustrate the connections (in terms of the local and global citations) between the 88 articles that had investigated V*f*M assessment. In our context, this understanding was facilitated by the relationship between the chronological distribution and pedigree of the V*f*M-related literature presented in Fig. 3, where the nodes represent the publications identified at Stage 2. The sizes of the nodes are proportionate to the number of their citations within the WoS and Scopus. The 'links' depict the relationships cited with one other in the 'pool' and reflect the interrelationships of the knowledge generated from them (Zhuge, 2006).

Among the links, the main path has been demonstrated by Carley et al. (1993) to be associated with the thematic or methodological transitions in developing a topic. Therefore, to further understand the main developments in V*f*M assessment, the *Pajek* software was employed (Mrvar and Batagelj, 2016). More specifically, the Search Path Link Count[2] algorithm was applied within the software to extract the main path. The main reason for doing so is to consider all citation relations that traverse through the nodes and further construct the development of the V*f*M assessment literature (Lucio-Arias and Leydesdorff, 2008). As shown in Fig. 3, the Search Path Link Count algorithm accounts for all possible search paths through the network emanating from an origin to identify the most important part of a citation network.

The main path in Fig. 3 (i.e., the link in red) comprises nodes 11, 19, 35, 41 and 64, in which Morallos and Amekudzi (2008) (node 11) investigated the advantages and disadvantages of V*f*M assessments used in practice in Australia, Canada, HK, SA and the UK, and noted that the PSC provides a measure of value. Continuing with this research, Morallos et al. (2009) (node 19) examined the application of V*f*M assessment in the United States (US). This was followed by Liang and Hu's (2017) (node 64) work on V*f*M assessment in China. In a recent study, Peng et al. (2014) (node 41) echoed Morallos and Amekudzi (2008) and re-examined the weakness and inadequacy of PSC. Moving beyond PSC, Tsamboulas et al. (2013) (node 35) proposed a Multi-Criteria Analysis (MCA) approach to assess V*f*M within a qualitative context. However, the most significant nodes, 7 and 24, are neither critical parts of the main path nor cited by several studies in the 'pool'. Further examination of Abdel Aziz (2007) (node 7) and Ng et al. (2012) (node 24) revealed that V*f*M was only mentioned as part of their framework for the successful delivery of PPPs. As such, they did not specifically tackle the issue of V*f*M and, therefore, had been isolated from the 'pool'.

This primary path analysis has revealed that the development of V*f*M assessment focused on: (1) its application in different countries; (2) constructing and evaluating PSC; and (3) assessing the qualitative aspects. Moreover, it is shown that the overall development of V*f*M assessment has been overlooked, and more importantly, research in V*f*M assessment has been fragmented rather than systematic. Evidence can be seen in Fig. 3, where such key nodes as 18, 30, 38, and 75 do not interact with any other nodes in the network. Hence, there is an urgent need to collectively identify and analyse all existing approaches to assessing V*f*M to create new knowledge to support the procurement of infrastructure projects.

3.3. Investigation-content analysis

A content analysis guided by the SWOT analysis was conducted at Stage 3 to diagnose the seven V*f*M assessment methods identified in Table 1. A SWOT analysis is widely acknowledged as a practical tool for evaluating organisational decision-making processes (Helms Marilyn, 2010; Emet and Merba, 2017). Hence, it was considered suitable for deepening our understanding of the characteristics of V*f*M assessment methods. As mentioned above, the PSC is the most widely used technique for assessing and determining V*f*M and choosing a procurement strategy for transport projects worldwide, such as in Australia, Canada, China, New Zealand, the UK and the US. It comprises the quantification of generic components (Fig. 4), including (1) raw PSC (base costing); (2) competitive neutrality; (3) transferable risk; and (4) retained risk

[1] Figure 2 was updated at the time of publication to show the latest trend. The analysis in Section 3.2 includes literature until 2019 at the time of investigation.

[2] The details of this algorithm can be found in Lucio-Arias and Leydesdorff (2008).

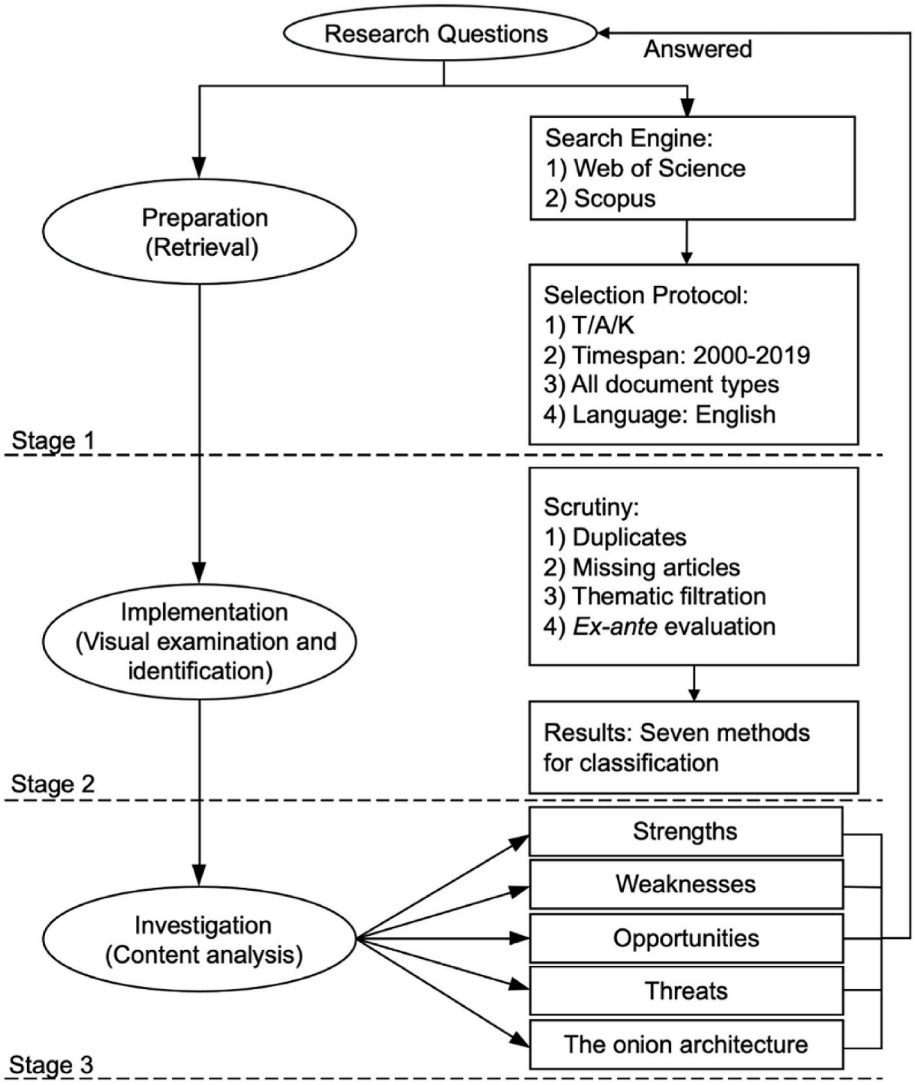

Fig. 1. Research approach.

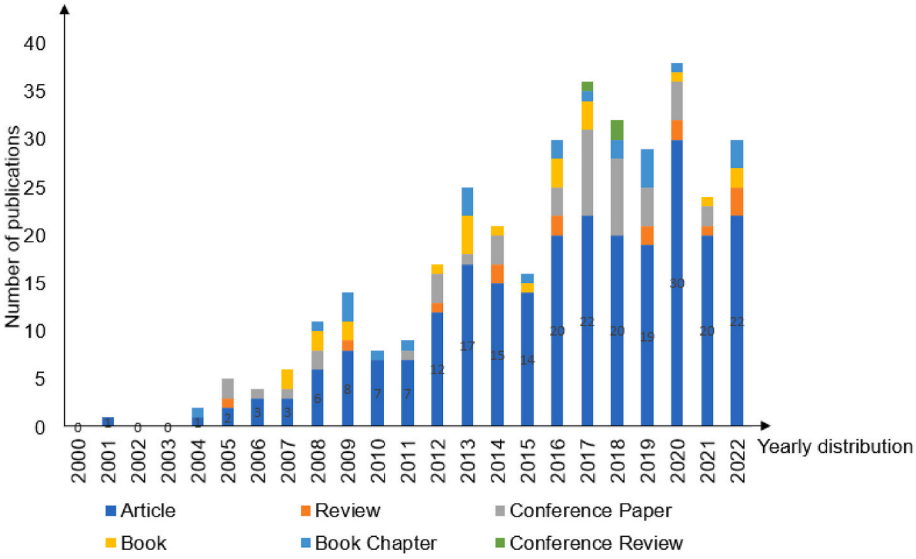

Fig. 2. Distribution of publications related to V*f*M.

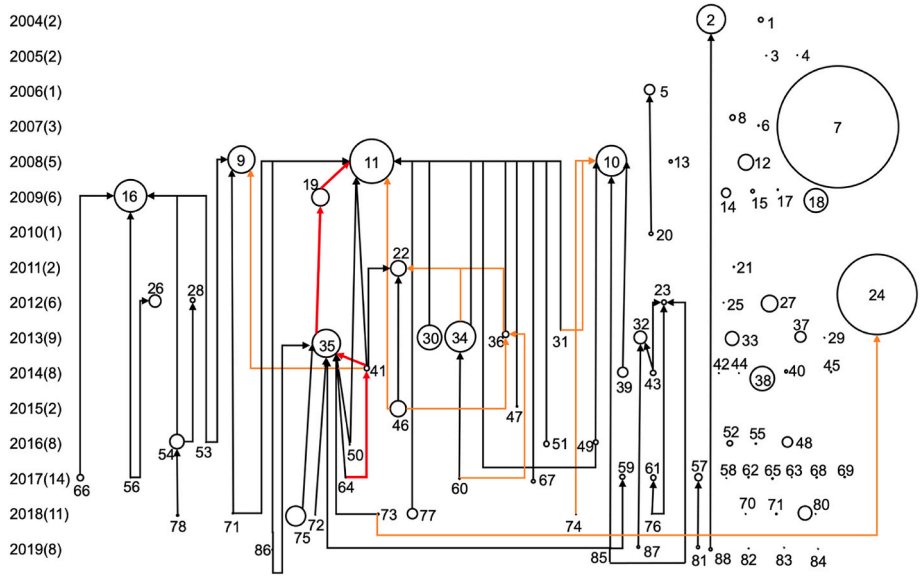

Fig. 3. Algorithmic historiography of the V*f*M assessment literature
Note: (1) Numbers in the bracket show the number of publications about V*f*M assessment in that year; (2) Links in orange are coloured to avoid confusion between the intersection of the links; and (3) The link in red is the main path. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 1
Fundamental research into V*f*M assessment methods.

Methods	Relevant Selected Research[a]
PSC	Miyamoto et al. (2005); Ball and King (2006); Abdel Aziz (2007); Queiroz (2007); Coulson (2008); Merna and Lamb (2009); Morallos et al. (2009); Reeves (2011); Ismail et al. (2012); Karmperis et al. (2012); Fantozzi et al. (2014); Vining and Boardman (2014); Opara et al. (2017); Kweun et al. (2018); Hu and Han (2018); Leigland (2018); Hang (2019); Wang and Li (2019)
Monte Carlo simulation	Miyamoto et al. (2005); Morallos et al. (2009); Aldrete et al. (2012); Peng and Liu (2013); Liang and Hu (2017)
Outline Business Case (OBC)	HM Treasury (2006); Cheung et al. (2009); UK Department for Transport (2013)
PPP-VALUE	Decorla-Souza (2014); Decorla-Souza and Lee (2017)
MCA	Tsamboulas et al. (2013)
Multi-objective Bayesian Network (BN)	Xie and Thomas Ng (2013)
CBA	Karmperis et al. (2012); Decorla-Souza et al. (2013); Decorla-Souza et al. (2016); DeCorla-Souza et al. (2017); Moore et al. (2017)

[a] Table 1 is based on the clustered 88 articles. However, due to space limitations only important publications are identified.

(Hromada, 2017; Decorla-Souza, 2018). Risk transfer influences the rationale and justification for using a PPI form of procurement (Makovšek and Moszoro, 2018; Cui et al., 2019). In this case, the PSC may draw on the Monte Carlo simulation to determine project sensitivities to variations in price, risks and uncertainties (Peng and Liu, 2013; Liang and Hu, 2017).

The UK government developed the OBC to improve the V*f*M assessment of infrastructure projects (HM Treasury, 2006). Underpinning the OBC is a quantitative assessment that compares PPP costs with conventional procurement forms. Thus, the OBC resembles the PSC (Department for Transport, 2013). Similarly, the US Federal Highway Administration's (FHA) recommendation of PPP-VALUE for assessing the V*f*M of transport projects is a derivative of the PSC (Decorla-Souza, 2014).

While MCA is often used to evaluate the environmental and safety

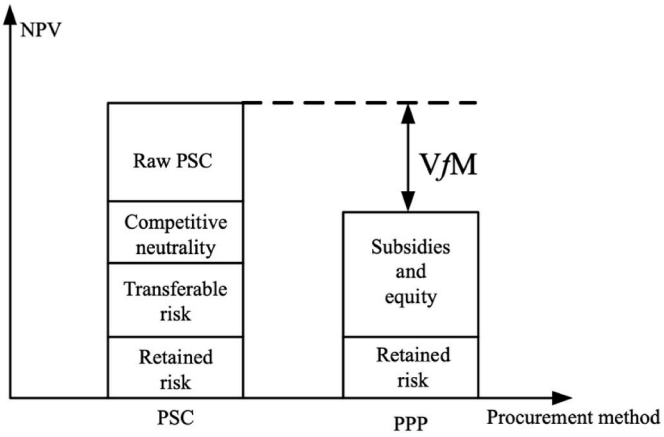

Fig. 4. Components of PSC and V*f*M.

impacts of projects, it has also been implemented by Tsamboulas et al. (2013) to determine value when employing PPPs. At this juncture, it needs to be pointed out that MCA is only applicable when PPPs have been demonstrated as a preferred procurement method. In essence, MCA is not intrinsically a decision-making technique but rather a tool for confirming the 'choice' of a selected procurement method. That is to say, MCA is restricted to dealing with the qualitative side of PSC and thus forms part of its decision-making toolkit. Additionally, multi-objective BN models proposed by Xie and Thomas Ng (2013) can support the use of PSC, particularly for non-financial aspects of the projects.

As well as the PSC-related methods above, CBA (also referred to as Benefit-Cost Analysis, BCA) can monetise the benefits and costs of a project from a broad perspective by attending to the question "whether benefits accrued to the public sector surpass the costs" (Decorla-Souza et al., 2013: p.32). The European Commission (2014) listed six steps for conducting CBA, involving: (1) presentation and discussion of socio-economic benefits along with project objectives; (2) clear project identification; (3) study of project feasibility and alternative options; (4) financial analysis; (5) economic analysis; and (6) risk assessment. It is outside the remit of this paper to explain the 'how' of the PSC and CBA,

but a detailed explanation can be found in the works of Decorla-Souza et al. (2016), Hu and Han (2018) and Hang (2019).

4. SWOT analysis

A SWOT encompasses an examination of internal attributes (strengths versus weaknesses) and external impacts (opportunities versus threats) (Ghazinoory et al., 2011). The internal attributes and external impacts within the context of the V*f*M techniques and procurement methods are now examined (Table 2). Since Monte Carlo simulation, OBC, PPP-VALUE, MCA, and Multi-objective BN were considered part of PSC (Section 3.3), the strengths and weaknesses analyses below focus on PSC and CBA as two core approaches.

4.1. Strengths

4.1.1. Quantification of financial benefits

Governments must evaluate the potential benefits of using PPPs and consider taxpayers' best interests (Broadbent and Laughlin, 2004). Therefore, the PSC is used to determine if it is financially beneficial to use a PPP and thus prevent taxpayers from funding a project (Cheung et al., 2009). A case in point is the Indian Bangalore Nelmangala National Highways 4 Project. Here, the PSC demonstrated that a saving of US$24.3 million from the public budget could be achieved using a PPI (Gopalkrishna and Karnam, 2015). While the PSC tends to overlook non-financial benefits (e.g., regional development, environmental impacts and public support), some governments, such as the US's PPP-VALUE, incorporate a form of non-quantitative analysis into assessing the viability of procurement routes (Almarri and Boussabaine, 2017; He et al., 2018; Sun et al., 2019). For instance, the PPP-VALUE method considers travel time saving and accident and emission reduction, which PSC has overlooked (Federal Highway Administration, 2012).

4.1.2. Simplified procurement selection process

The PSC process is relatively straightforward to implement as it focuses on comparing the NPV of an asset over its lifecycle with and without the private sector's financial contributions (Zwalf et al., 2017; Kweun et al., 2018). In stark contrast, CBA is more complex to implement as there is a need to quantify the costs and benefits of all possible options that can be realised. While CBA goes some way to providing insights into the expected benefits of transport investments, it is prone to producing inaccurate estimates. It thus has several shortcomings, for example, "pricing the priceless benefits", "distorting the future using inappropriate discount rates", and "ineffective capturing dynamic uncertainties" (Ackerman, 2008: p. 3–7).

Table 2
Comparison of V*f*M assessment techniques.

V*f*M Assessment Techniques	Strengths	Weaknesses
PSC Monte Carlo simulation OBC PPP-VALUE MCA Multi-objective BN	•Quantification of financial benefits •The simplified procurement selection process	•Asymmetry in cost comparison •Contentious discount rate •Undefined components • Subjective assumptions and inaccurate estimate
CBA	• Decision-making for a broader context • Comprehensive evaluation	• Time-consuming and non-standardised process
V*f*M Assessment Techniques	**Opportunities**	**Threats**
PSC/CBA	• Prosperous market • Scientific and technical stimulus	• Inclination

4.1.3. Decision-making for a wider context

Conventionally, the PSC is only applied at the inception of a project to determine whether a PPI procurement method should be used. However, CBA is applicable for decision-making for multiple stages over a project's lifecycle. Typically, it can be implemented to develop a business case for a transport project. Furthermore, CBA is regularly used in the post-construction stage by monetising benefits, though it will depend on the benefit-cost ratio (Lam and Gale, 2014; Rouhani et al., 2016; Almarri and Boussabaine, 2017). Hence, CBA can provide governments with insight into the V*f*M of alternative procurement methods and an understanding of the economic and social benefits of the project (Decorla-Souza and Lee, 2017).

4.1.4. Comprehensive evaluation

The PSC, as addressed above, is a form of cost-oriented evaluation, overlooking a series of social and environmental benefits (i.e., creation of job opportunities and environmental impacts) (Ng et al., 2012; Peng and Liu, 2013). For instance, the PSC was applied to justify the approach used to deliver the M1-A1 project in the UK. The main reason for choosing the build-finance-operate model was to obtain a cost-saving of £84 m, provided by the private sector's financial contribution (Mackie and Smith, 2005). In contrast, the CBA can perform an overarching evaluation covering both costs/economic risks and social benefits (Decorla-Souza et al., 2013). By integrating traffic forecasts and revenue analysis, CBA provides decision-makers with a clear pathway to whether a project should move to its next stage of development (Cruz and Sarmento, 2020). For example, the French government applied this approach when deciding whether its high-speed rail line (HSRL) would pass through the suburb of 'Métropoles du Sud' or 'Côte d'Azur'. Due to higher ridership forecasts, ' Métropoles du Sud' was chosen (Hyard, 2012). Of note, major transport projects funded by the European Union are explicitly required to conduct a rigorous CBA (The European Commission, 2014).

4.2. Weaknesses

4.2.1. Asymmetry in cost comparison

To recap, the PSC generates a hypothetical scenario to compare PPI and conventional procurement options. In this case, it is meaningless to benchmark the theoretical costs of conventional procurement approaches with actual bids relating to PPPs (Gopalkrishna and Karnam, 2015). Even when making financial comparisons, the discount rates used for the PSC and the relevant shadow bid model[3] (SBM) vary in practice to accommodate the specific risks of two different procurement approaches (Zwalf et al., 2017). While governments tend to use a social discount rate (SDR) in PSC, organisations from the private sector (i.e., private Special Purpose Vehicles) prefer the weighted average cost of capital for the cost estimate of the projects to be delivered by PPI (Decorla-Souza et al., 2016). This inconsistency results from using two different discount rates in the cost comparison of a project, which leads to an asymmetric estimate and has an adverse impact on PSC's reliability (Zwalf et al., 2017).

4.2.2. Contentious discount rate

A vital aspect of the PSC calculation is selecting an appropriate discount rate (Zwalf et al., 2017). Technically, there are five types of discount rates available: (1) social rate of time preferences (SRPT); (2) social opportunity cost of capital (SOCC); (3) mixture of the SRPT and SOCC; (4) equity premium; and (5) risk-free interest rate (Sarmento, 2010). While several studies have attempted to secure an appropriate discount rate, the choice remains contentious.

[3] SBM is the Responsible Agency's best estimate of a private party bid price (in net present value/cost terms) to deliver the output specification under a PPP project structure (The Treasury of New South Wales, 2017: p.48).

A small change in the discount rate can distort the result of the procurement selection process (Grout, 2003; Zwalf et al., 2017; Wang, 2018). A high discount rate often favours selecting PPI forms to deliver projects (Parks and Terhart, 2009; Contreras, 2014). Take the UK as an example. The rate required by the government was set at 6% in the 1990s (Shaoul, 2005). Such a high discount rate led to an overestimate of the PSC, favouring the option of PPIs (Opara et al., 2017). Consequently, the UK government had to lower the rate to 3.5% to enable a 'fairer' comparison between PPIs and conventional procurement methods (Hodgson and Corrigan, 2005). As a result, there have been clarion calls for standardised discount rates for all procurement options for transparency and to enable 'apples to be compared with apples' (Reeves, 2015; Liang and Hu, 2017; Kweun et al., 2018).

4.2.3. Undefined components

Governments are reluctant to publicise the process and components of PSC, as often the estimates of many transport PPPs subjected to cost overruns indicate a preference for conventional procurement approaches to deliver the projects (Bayliss and Van Waeyenberge, 2018). Moreover, different public authorities tend to use distinct components for their PSCs to suit specific risks (Chen et al., 2016). The PSC adopted by the FHA in the US (2012) covers financing costs, retained risk, transferable risk and competitive neutrality. In the UK, the PSC that has been devised for road/railway projects comprises the costs and risks of the asset's construction, operations and maintenance (Bain, 2010). In sum, there are no universally accepted components of the PSC for transport projects (Department for Transport, 2017). These variations have led to an inconsistency of the PSC-oriented estimates, adversely affecting the reliability of the results regarding whether PPI should be used (Henjewele et al., 2012; Cruz and Marques, 2013; Reeves, 2015).

4.2.4. Subjective assumptions and inaccurate estimate

An underlying assumption with PSC is that PPI-type projects can provide higher levels of service quality to the public sector at a lower cost. However, many have been subjected to schedule or budget overruns and even contract terminations (Vining and Boardman, 2014; Chen et al., 2016). An investigation of European road projects has indicated that PPPs consume 24% more costs than conventional procurement approaches (Blanc-Brude et al., 2009). This result contradicts the claim that PPPs provide a cost-efficient, timely and enhanced delivery process. The first eight UK road projects procured using the private finance initiative (PFI) could have saved £100 m if the conventional procurement forms had been selected (Edwards et al., 2004). Inaccurate estimating due to optimism bias, amongst a range of other factors, has been attributable to the cost increases of these PFI projects (Edwards et al., 2004).

As previously mentioned, risk transfer is an essential component of the PSC, which can be unsuccessful if risk quantification and assessment are inaccurate Fields (Aldrete et al., 2012). There have been cases reporting that disproportioned risks transferred to the private-sector entities led to decreased ridership in some transport PPPs (Siemiatycki and Friedman, 2012). More importantly, an inaccurate risk quantification can skew the decision-making process in selecting a procurement option (Reeves, 2013; Patil and Laishram, 2016; Decorla-Souza and Farajian, 2017; Opara and Rouse, 2019).

4.2.5. Time-consuming and non-standardised process

As noted above, conducting a CBA is a time-consuming process, requiring a complete evaluation of all possible options (Grimsey and Lewis, 2005). However, monetising all alternatives to evaluate them is costly and impractical, particularly in the case of large-scale transport projects associated with many uncertain issues (OECD, 2008).

Another drawback of CBA relates to the complexities of determining the risk premium of the social discount rate. An excessive risk premium is provided to the private sector to bear all transferred risks, hurting taxpayers' pockets (Makovšek and Moszoro, 2018). However, there are limited official guidelines and/or practice codes for determining an appropriate risk premium for PPI projects (Freeman et al., 2018).

4.3. Opportunities

4.3.1. Prosperous market

Over the past decade, demand has increased to modify existing and construct new transport infrastructure in many countries worldwide due to population growth, demographic changes and to ease congestion in major cities (Girmscheid, 2009; Sing et al., 2019). As a result, the UK Government invested £600 billion to develop its domestic transport networks (HM Treasury, 2018). Similarly, the Commonwealth Government of Australia announced that AU$110 billion would be invested in the next decade to deliver vital transport infrastructure (Australian Government, 2021). Yet, in an era of austerity, which the COVID-19 pandemic has exacerbated, governments have turned to the private sector for assistance to deliver much-needed transport infrastructure (Love et al., 2021). The upshot is that V*f*M assessment is now a core feature of the procurement decision-making process (Opara and Rouse, 2019). Despite the importance of V*f*M assessment, prevailing approaches have been heavily criticised, as identified in this paper.

4.3.2. Scientific and technical stimulus

As V*f*M assessment forms a mandatory part of the PPI procurement decision-making process in developed and developing countries, many studies have ameliorated its practice (Shaoul, 2011; Tsamboulas et al., 2013; Jasiukevicius and Vasiliauskaite, 2018). For instance, Monte Carlo simulation quantifies risks accurately (Aldrete et al., 2012). Similarly, new decision-making models based on the Bayesian Network were developed by Zhao et al. (2022b) to quantify the significance of asset functionality in the V*f*M assessment of transport projects. Building Information Modelling has also been proposed to improve the cost estimates of V*f*M assessment (Ren et al., 2019). Although controversy still pervades in V*f*M assessment, the contributions above have led to developing current practices dominated by PSC and CBA.

4.4. Threats

'Inclination', referred to as the preference of a particular procurement approach, should not exist in governments' decision-making process of infrastructure project delivery (Eadie et al., 2013). However, due to budget capital constraints, many governments employ PPIs rather than conventional procurement methods (Loxley, 2012; HM Treasury, 2020). Although it may seem legitimate to procure transport projects via PPIs due to limited budget in the short term, governments should be wary of the profit guarantees/subsidies they have to provide as incentives to attract PPIs (Reeves, 2011; Bayliss and Van Waeyenberge, 2018). With a tendency to involve a private entity's financial contribution to projects, the PSCs of many transport projects were artificially made by the clients (i.e., governments) to indicate that using the conventional procurement method was more expensive than that of PPI (Hodgson and Corrigan, 2005; Wall and Connolly, 2009; Whiteside, 2020). Essentially, the UK's NAO (2011; 2013) has criticised the tendency to employ PPI in the V*f*M assessment, leading to the unreliable results of PSC.

5. Future research directions and implications for policy

The SWOT conducted above outlined the critical issues of practice in V*f*M assessment by addressing our first research question. We now seek to answer our second question, which aims to determine the improvements needed to ensure better V*f*M assessment of transport infrastructure projects. In doing so, policy implications are proposed to overcome the weaknesses and threats identified from our SWOT analysis.

Such implications are essential, as Hodge and Greve (2017) have concluded that political and governance strengths are more emphasised

than V*f*M in determining the success of PPPs. Our proposed 'onion' architecture governs the discussion on the nexus between future research directions and policy implications (Fig. 5). According to Palermo (2008), the 'onion' architecture is appropriate for "long-lived business applications as well as applications with complex behaviour'". This suits the complex nature of V*f*M, and the long-term contractual arrangements of PPPs. In addition, the fundamental rule of 'onion' architecture is that all couplings are toward the centre (Palermo, 2008). Put simply, our proposed directions for future research below can individually (decoupled) and collectively (coupled) enhance V*f*M assessment at the centre. With the cultural change and data/information acquisition scheme on the edge, our four systematic research directions can help mitigate the identified weaknesses and threats and reinforce strengths and opportunities.

5.1. Direction I: consistent ways of viewing VfM

The importance of V*f*M cannot be understated. Flanagan (2014) has considered it the most important issue for all clients and businesses. At the very least, it has become the golden threshold for a PPP to be viable. Yet, our review has uncovered it to be an ambiguous concept. In practice, the UK's Construction Leadership Council (2018) states a lack of "an industry-wide definition of value that considers more than capital cost'' (p.4). This is not wrong due to the variability of governments' goals. However, problems could arise because McKevitt (2015) argues such ambiguity affects how to assess and when to declare V*f*M is achieved.

Hence, we proffer two lines of enquiries: (1) a sector-specific definition of V*f*M and its stakeholders; and (2) alternative agents to engage with assessing V*f*M. For the former, Cui et al. (2018) find that it was common for the public attitudes and other stakeholders' expectations of V*f*M to be ignored. While we have seen Zhao et al. (2022a) propose the idea of public V*f*M and assessment of transport infrastructure's V*f*M from such aspects as service, environment, distribution, resilience, and social inclusion, research about defining its meaning is not proportionate to the abundant volumes of transport PPPs.

For the latter, it is worth considering the private sector's V*f*M assessment for the public sector. This view is based on: (1) the private sector is the main body to finance, design, build, and/or operate the asset and is considered to have the expertise to do so (natural advantage); and (2) the public sector has a tradition of outsourcing infrastructure procurement and loses the capacity to do so over the time horizon (external impetus).

Coupled with the definition of V*f*M is 'how' it is perceived and 'what' (i.e., broader impacts) should be captured in future studies. Currently, we have been accustomed to the use of V*f*M to justify the selection of a PPP at the front end. However, Zhao et al. (2022a) suggest that V*f*M should be adopted as "a transferrable tool not only for making *ex-ante* decisions but also for monitoring and (*ex-post*) evaluation of projects in their operational phase" (p.69). Failure to do so would divert a government's initial V*f*M goals and their PPP project's progress (Samset and Christensen, 2017).

While several studies have examined PPPs' performance against the traditional approach, they predominantly focus on time and cost (e.g., Ramsey and El Asmar, 2015; Petersen, 2019; Verweij and van Meerkerk, 2021). By way of explanations, an *ex-post* evaluation needs to reflect the V*f*M-related criteria applied at the project's outset. We acknowledge that inherent uncertainties over a project's life cycle may distort and divert the initially expected V*f*M. Still, accepting a marginal difference between perceived, expected, and materialised V*f*Ms remains pivotal. Although addressing *ex-ante* V*f*M criteria during an *ex-post* evaluation is essential for ensuring value is delivered and benefits realised, we have yet to see any evidence that this practice is undertaken (Samset and Christensen, 2017; Zhao et al., 2022a).

5.2. Direction II: advancements in VfM assessment techniques

Our review has broadly classified existing V*f*M assessment techniques into PSC and CBA. These techniques have strengths in quantifying financial benefits and simplifying the procurement selection process. Under the auspices of a standardised V*f*M definition, we need to be cognisant of the weaknesses of V*f*M assessment methods so that their potential can be maximised. There are two aspects here that can be accounted for in the future.

First, research can be conducted to guide the selection of an appropriate discount rate. Several options are available (e.g., social opportunity cost, social time preference, and the capital asset pricing model) (Stafford, 2011). Still, understanding their rationale and sensitivity to the assessment result must be improved. Associated with the discount rate is the consideration of risk-sharing rather than risk transfer/allocation, which is prevalent in the existing literature. We suggest focusing on risk-sharing as, more often than not, the touted risk transfer to the private partner exists only in the 'ideal' world. For example, due to COVID-19, we have seen demand risk being transferred to the asset owner and the UK Department for Transport (2022) having to pay £20.5219 billion from 2020 to 2022. It is not about forecasting the future

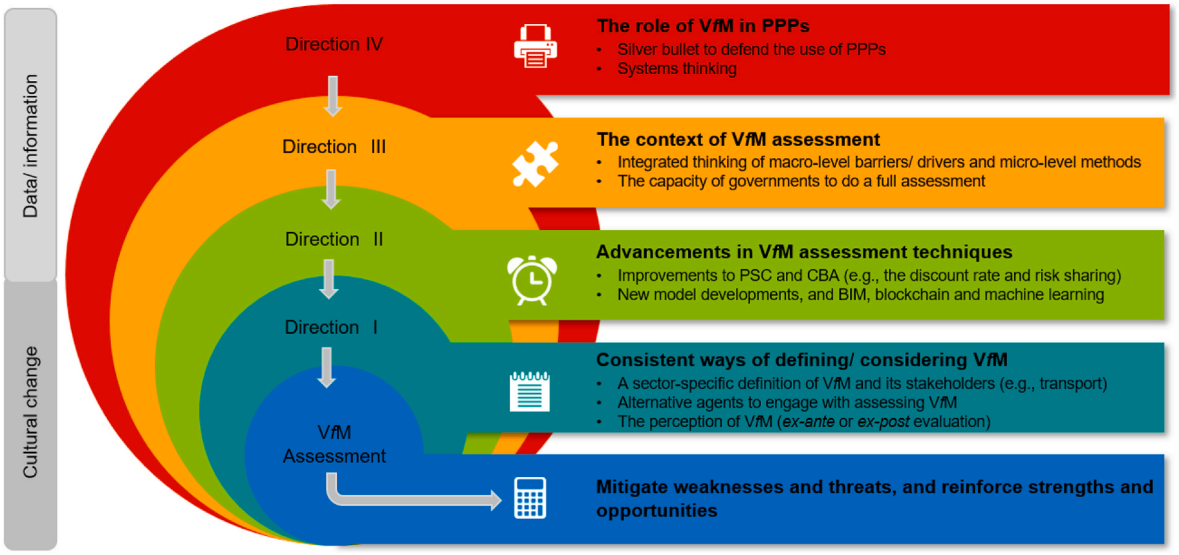

Fig. 5. The V*f*M 'onion' architecture.

here. Still, future studies must consider identifying and, more importantly, managing such unmeasurable risks when preparing for a V*f*M assessment. The work of Casady and Baxter (2020), where a comprehensive revision of *force majeure* PPP contract provisions was called for, may well be a progressive direction in this domain.

Second, future research should develop new techniques since the review has identified scientific and technical stimulus as an opportunity for re-evaluating V*f*M assessment. This need stems from the scrapping of PSC in the UK (NAO, 2013) and Flyvbjerg and Bester's (2021) suggestion that CBA is broken. To date, however, we are only able to identify the use of regional equilibrium (Rouhani et al., 2016), intergenerational redistributive effects model (Penyalver et al., 2019), and dynamic discrete choice model (Zhao et al., 2022b) for the VfM assessment of transport projects if not all. It should be noted that we are not negating the beneficial role of PSC and CBA in public expenditure.

We suggest that future studies also look at applying novel technologies to help assess V*f*M. Whyte (2019) has demonstrated the ability of digital information to transform project delivery models. For example, Ren et al. (2019) and Yuan et al. (2020) have adopted building information modelling in V*f*M-related PPP evaluation. These set a foundation for others, such as blockchain and machine learning, to be investigated.

5.3. Direction III: the context of VfM assessment

Undoubtedly, the V*f*M assessment is conducted within each jurisdiction's context. Rye et al. (2021) explained that politics pre-dominantly shape how people conceive of partnership/franchising to bus services in two regions in the UK. It is appreciable that existing literature has dealt with macro-level institutional (Matinheikki et al., 2021) and political (Peña-Miguel and Cuadrado-Ballesteros, 2021) drivers/barriers to PPPs or micro-level V*f*M assessment methods as the review has unfolded.

Only sometimes, however, is integrated thinking of why V*f*M is assessed as it currently is. Or, conversely, does V*f*M assessment contribute to achieving the macro-intentions that initiated PPPs in the first place, for example, the social, environmental, and economic benefits as stated in the Local Government Association (2022)? Future studies can embrace this missing link as research has confirmed that politics and V*f*M are critical factors influencing the success of PPPs (Liu et al., 2015).

Another aspect that should be made aware of under a particular context is that V*f*M assessment methods may differ. It is reasonable to assume that the UK practice may not apply in some developing countries. For example, the governments of developing countries are generally concerned about raising project financing and constructing roads when using PPPs (Cherkos and Jha, 2021). However, such governments' capacity to do a full-scale V*f*M assessment like that undertaken in the UK is questionable.

Many developing countries' governments need more skills and knowledge about the V*f*M assessment process to realize the benefits and deliver value in their projects (Burger and Hawkesworth, 2011). While studies on comparing V*f*M assessment in different countries are limited, we suggest future studies focus on enhancing the ability to undertake a proper V*f*M assessment when a standardised V*f*M concept and associated techniques are available. Faced with the threat (i.e., political manipulation) unveiled above, studies on understanding the macro-level intentions and enhancing assessment abilities can serve as promising countermeasures.

5.4. Direction IV: the role of VfM in PPPs

While various topics associated with PPPs are controversial, there is a consensus that they should provide better V*f*M than conventional procurement approaches. In the UK, PPPs became popular in 1992, when V*f*M was not addressed. However, the UK Government proposed to embed a V*f*M assessment into their PFI evaluation process in 1999 (Private Finance Treasury Taskforce, 1999). Since the introduction of V*f*M, it has become a silver bullet to defend using PPPs, even though the evidence remains anecdotal. At this juncture, we could not help but ask: is V*f*M assessment a panacea for all the problems that may emerge over PPPs' long-term project life cycle? Our review suggests the opposite, given the limited abilities (i.e., weaknesses and opportunities) of the existing methods to provide a comprehensive assessment. This does not mean the project itself is a 'failure' because it could still benefit our society, as depicted in the toll motorways case by de Albornoz et al. (2021).

Hence, we call for future studies on V*f*M assessment to consider addressing the following research question: How *can VfM continue to play a role in PPPs after they are selected as the preferred procurement approach*? One direction, according to Flanagan (2014), could be channelled into the combination of not only 'hard' systems (e.g., project planning, scheduling and control) but also 'soft' systems (e.g., people, actions, reactions and intentions) to look at complex systems (e.g., PPPs). It may provide a lens for future studies to apply *procurement management* and *network approach* from a process perspective to assess V*f*M.

5.5. Policy implications

As indicated above, four future research directions have been proposed to mitigate the weaknesses and threats the V*f*M assessment techniques face. Simultaneously, it sheds light on some policy implications to develop supporting initiatives. The integrity of the V*f*M assessment is jeopardised by 'manipulation' and the expectation to transfer all risks to the private sector. Here, the culture needs to change to a real partnering one (e.g., risk-sharing), or the policy should be formulated to incentivise partners to work on common goals (e.g., delivering valuable projects). This underlies a leadership shift from finding faulty parties to finding solutions. For instance, the incoming expiry (see Infrastructure and Projects Authority, 2022) of an abundance of PPPs in the UK provides an opportunity for the public sector to exploit improvements to tested techniques and established routines from experience and explore new cultural thinking, technologies, and processes for future transport infrastructure projects.

Where the culture takes time to foster, the immediate policy could focus on the data/information needed for V*f*M assessment. As stated in the Department of Transport (2017) and Bayliss and Van Waeyenberge (2018), data acquisition has long been challenging for a practical V*f*M assessment. A database containing the essential data of previously procured transport projects is needed to resolve this issue (Love et al., 2023a). This database would enable governments to store and manage the lifecycle data of their transport assets, which will help them learn lessons for the decision-making of future project delivery (Love et al., 2023a).

Such a database can be combined with the second direction (i.e., advancements in V*f*M assessment techniques), as Aben et al. (2021) have uncovered how digital technology helps gather, share, and transform information in PPPs. For example, given that a transport infrastructure project is initiated to provide end-users with services to satisfy their transportation demand (Filion and McSpurren, 2007), the public sector should acquire information about end-users satisfaction from their projects, which can be uploaded to the database and ensure essential data relevant to asset's service quality would be available for V*f*M assessment.

A rigorous and strict accounting mechanism to incentivise the public sector to acquire information from end-users can be implemented to improve data transparency and public accountability (Forrer et al., 2010; Stafford and Stapleton, 2017). Additionally, as mentioned above, the private sector can be mobilised to assist the public sector in data acquisition and access as they are better positioned to assess and estimate impacts and costs.

6. Conclusions

The assessment of V*f*M is indispensable in selecting an appropriate procurement strategy for transport projects, particularly decisions between forms of PPI and conventional procurement. It aims to create a definitive decision during the inception stage of projects so that the infrastructure asset can be successfully delivered. Nevertheless, existing techniques (e.g., PSC and CBA) have been widely criticised for producing inaccurate assessments of V*f*M. Despite this, a holistic review of extant V*f*M assessment is limited in the literature, which this paper attempted to address by conducting a systematic review and suggesting future research directions and policy implications for headway to be made.

A total of 88 publications from 2000 to 2022 have been systematically identified and reviewed. Then, seven popular methods that can be clustered into the realms of PSC and CBA were identified. Such techniques were examined by using a SWOT analysis. Based on the analysis results, four thematic future research directions have been conceptualised in an 'onion' architecture. These are (1) consistent ways of defining/considering V*f*M; (2) advancements in V*f*M assessment techniques; (3) the context within which V*f*M is assessed; and (4) the role of V*f*M in PPPs. Implications regarding the necessary culture change and the data/information access have been discussed to support the development. To this end, the contributions of this paper are twofold: (1) present insights into the strengths, weaknesses, opportunities, and threats of existing V*f*M assessment techniques; and (2) provide the public sector with a new framing to formulate transport infrastructure procurement policy.

A limitation of our systematic review should also be pointed out. While the HistCite software generated a profound histography of the V*f*M assessment literature, its citation-based rules may have overlooked more recent articles as citations tend to increase over time. Thus, future longitudinal studies will need to track deviations in the main path we have identified in our histography. Adopting the HistCite software with other mapping tools, such as VoSviwer and CiteSpace, would also be useful to undertake a bibliometric and comparative analysis of the V*f*M assessment literature for varying procurement contexts.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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