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Evaluation of the Promotion of Through-Life Management in Public Private Partnerships for Infrastructure

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Abstract: One justification of public private partnerships (PPP) is the alleged benefit they offer in terms of through-life management (TLM). Aiming at an evaluation of this claim, the dominant reasoning connecting PPPs and TLM is first defined: *In creating a single point of responsibility and a long temporal involvement, the PPP model provides an effective incentive to implement TLM.* This reasoning is first evaluated through prior large scale studies and through two case studies undertaken by the authors. No substantial evidence of TLM benefits is found. To identify the causes for this gap between intention and achievement, a critical review of the PPP literature supported by insights from management and organization theory is undertaken. Four problems in the reasoning are found to explain the gap: fragmentation is factually prevailing; not all parties in PPPs intend to have a long term commitment to the project; there may be competing incentives for some parties; and the effort to achieve the change and learning necessary for TLM may be missing. It is concluded that for the TLM benefits to be achieved, the PPP model has to be redesigned to secure incentivisation towards TLM and to incorporate TLM mechanisms at the level of the production system.

Keywords: through-life management; public-private partnerships; private finance initiative; infrastructure procurement

1. Introduction

Public Private Partnerships (PPP), including Private Finance Initiatives (PFI), are now a common form of governance for public infrastructure development and management [1]. One of the justifications given by governments for the decision to embark on such projects is that they provide better Through-Life Management (TLM) of the built assets and the associated services provided. However, it is not possible to find a policy document presenting numerical targets or prior evidence for such improvement. The scholarly literature does not seem to provide much support either; in an analysis of 1400 publications on PPP, Roehrich *et al.* [2] find relatively limited conceptualization and in-depth empirical investigation, despite the scale and significance of the PPP phenomenon. In order to address evidence gaps, particularly with regard to healthcare PPPs, they recommend exploring the impact of incentive mechanisms and risk management procedures on health service performance throughout the extended project life-cycle. Notably, the literature they analyse covers PPPs generally, thus the evidence gap is not merely limited to healthcare.

In alignment with the evidence gap discussed above, the aim in this paper is to critically evaluate the claim that PPPs promote effective TLM, focusing on the Private Finance Initiative (PFI), widely deployed in the UK.

We begin with a discussion of the research question and strategy adopted. The considerable variety of PPPs and the nature of these arrangements are briefly considered, with a focus on infrastructure development. The place of PFIs within the range of options is identified. The rationale for their adoption is discussed, with a particular emphasis on the TLM argument. The various approaches to TLM are then reviewed and a framework for understanding it is presented.

The subsequent evaluation is in three parts. The first addresses the outcomes of PPP schemes from a TLM viewpoint and draws on published systematic reviews of the PPP literature and studies using large samples. The second presents two UK case studies: a PFI scheme to replace ageing hospital facilities; and a new build programme for primary schools that set out to provide an alternative, state funded strategy to achieving through-life benefits. Both literature reviews and case studies reveal a gap between prediction and outcome in PPP schemes. In the third part, we attempt to explain this discrepancy through an empirically and theoretically informed critique of the reasoning, based on economic theory that underlies the TLM claims for PFIs. Finally, we make some suggestions as to how PFI/PPP projects can be better designed to improve outcomes.

2. Research Question and Strategy

This paper sets out to answer the question: do PPPs for infrastructure promote TLM? Both academic and government literature offer the policy prediction that they do. In addition to assessing the evidence for this, we critique the theoretical assumption, which underlies the prediction: that the financial incentives provided by PPPs are strong enough in themselves to ensure that project participants engage in long term planning to ensure the maximum operating efficiency of buildings.

The argument is relatively complex, having the following elements:

(1) a description of the PPP procurement route and its TLM rationale
(2) a definition of effective TLM
(3) evidence from large scale studies and systematic reviews on the implementation outcomes of TLM in PPPs
(4) evidence from two case studies on the problems of implementing TLM on both a PPP and a non-PPP procurement route
(5) a critique of the TLM rationale for PPPs, based on a synthesis of the PPP literature with insights from management and organisation theory
(6) an analysis of the effectiveness of TLM implementation, using the definition of TLM developed above, as a standard
(7) a discussion of the significance of the above for the implementation of TLM in future public procurement

The TLM rationale for PPPs is based on an understanding of economic theory, which relies on financial incentives as the chief determinant of behaviour. This understanding is first outlined. The theory and practice of TLM are then explored in order to develop an operational definition that can function as a standard for effective implementation.

An initial evaluation of the TLM effects of PPPs is performed through an analysis of the published literature. There is a great deal of literature available and the short review provided here is necessarily selective. Two types of papers are included. First, large scale quantitative studies, of which there are only two available. Second, currently published reviews of the literature. These types of studies are selected as the most appropriate for giving an overview of the field. While the analysis of such studies is necessarily highly abstract and 'third hand', we believe that it is sufficient to demonstrate a *prima facie* lack of effective TLM in PPPs, particularly as there is a high level of agreement on this matter in the literature.

It should be noted that the case studies were carried out simultaneously with the literature review and were performed in order to achieve a comprehensive understanding of how TLM issues were handled on the built environment projects investigated. The cases were selected in order to provide insights from two different procurement routes, one of which was a PPP. Virtually any built environment project would have been suitable for these studies, though the spread of procurement routes offers an additional richness to the insights offered. A range of qualitative techniques were employed in order to put together a comprehensive picture. For the purpose of this paper, relevant findings from the case studies were then used in order to evaluate the economic rationale for PPPs. Of course, this method suffers from the opposite limitation to the initial literature review; while the findings are unambiguous, their generalisability may be questioned. Nevertheless, in this way, the case studies fulfil a common function of qualitative research in bringing high-flown theoretical flights of fancy back to earth.

In the light of these findings, the argument then focuses on a critique of the economic rationale. This section draws on observations of the functioning of PPPs from published built environment research. It also introduces principles from management and organisation theory, which help explain these observations. We have selected the most robust studies available and the findings presented are broadly representative of the literature as a whole. Ultimately, it must be recognised that the published literature, whatever its limitations, represents the best evidence currently available.

It might also be argued that using the findings in this manner involves an undue measure of abstraction. It might be asked whether generalisation is possible here. As with our case studies we ask the reader to consider their generic significance in a logical manner. It is unlikely, for instance that Leiringer's [3] finding—on the difficulty of allocating risk to those most able to control it—is significant only for the particular cases he has studied. It is in order to facilitate such interpretation that we have introduced insights from theoretical literature, which strengthen and confirm the reported findings. This section concludes with an analysis of the available evidence for TLM implementation, which uses the definition of TLM developed earlier as a set of criteria for effective implementation.

The argument cannot, of course, be fully conclusive. We do not go so far as to suggest that PPPs do nothing to promote TLM, though theory and evidence do seem to point in this direction. On the other hand, we do contend that there is sufficient reason to believe that adopting a PPP route is in itself insufficient for effective implementation of TLM. The paper concludes with a discussion of what other measures may be necessary to achieve this goal.

3. Public Private Partnerships

In this section, the variety and definition of PPPs are first examined, and then the argument for the TLM benefits of PPPs is outlined.

3.1. Variety

There exist a wide variety of types of PPPs, and confusion has sometimes arisen from the failure to distinguish clearly between them [4,5]. Five types are identified, namely, institutional risk sharing; long-term infrastructure contracts; public policy networks; civil society and community developments; and urban renewal [6]. Even focusing solely in major infrastructure projects we find a wide range of schemes, including: Build, Operate and Renewal of Concession; Build, Operate and Transfer; Build, Own, Operate and Transfer; Build, Rent and Transfer; Build, Transfer and Operate; Design, Build, Finance and Operate; Design, Construct, Manage and Finance; Modernise, Operate and Transfer; Modernise, Own, Operate and Transfer; Rehabilitate, Own and Transfer [7].

3.2. Definition

In view of the wide variety of approaches, it is perhaps unsurprising that an agreed definition is somewhat elusive. Table 1 provides an overview of prominent ones.

Table 1. Various definitions of PPP [8].

Source	Definition
HM Treasury [9]	An agreement between two or more entities that enables them to work cooperatively towards shared or compatible objectives and in which there is some degree of shared authority and responsibility, joint investment of resources, shared risk taking and mutual benefits.
The World Bank [10]	The term "public-private partnership" has taken on a very broad meaning. The key elements however are, the existence of a "partnership" style approach to the provision of infrastructure as opposed to an "arms-length" supplier relationship [. . .] Either each party takes responsibilities for an element of the total enterprise and they work together, or both parties take joint responsibilities for each element [. . .] A PPP involves sharing of risk, responsibility and reward and it is undertaken in those circumstances when there is a value-for-money benefit for the tax payers.
European Commission [11]	A partnership is an agreement between two or more parties who have agreed to work cooperatively toward sharing and/or compatible objectives and in which there is shared authority and responsibility; joint investment of resources; shared liability or risk-taking; and ideally mutual benefits.
Canadian Council for Public Private Partnerships [12]	PPP is a cooperative venture between the public and private sectors, built on the expertise of each partner that best meets clearly defined public needs through the appropriate allocation of risks and rewards.

It seems fair to say that PPP is an evolving concept and that such projects take many forms around the world [13], though in all cases they consist of the pursuit of public policy through a long term agreement between a public agency and a private sector partner, which involves bundling the different life cycle phases of an asset in order to achieve the most rational distribution of risk. However, it is not unreasonable to treat an infrastructure PPP as a cooperative arrangement between public and private sectors for the sharing of risks and responsibilities for the provision of infrastructure and infrastructure based services [1,13,14]. Crucially, a PPP involves the purchase of a stream of services defined in a detailed service agreement under specified terms and conditions.

In the UK, PFI was introduced in 1992. It has become the form of Public Private Partnership used most frequently during the last 20 years [15]. In 2012, the UK government introduced a new approach in England, named PF2 with a view to further improving PFIs. An attempt to position PFI within PPP can be found in a House of Commons research paper [16]. It acknowledges that PFI is "also a form of public private partnership that marries a public procurement programme, where the public sector purchases capital items from the private sector, to an extension of contracting-out, where public services are contracted from the private sector" [16] (p. 9). The paper [16] also offers differentiation of PFIs from other form of private sector engagement for the provision of public services. Accordingly, "PFI differs from privatisation in that the public sector retains a substantial role in PFI projects, either as the main purchaser of services or as an essential enabler of the project. It differs from contracting out in that the private sector provides the capital asset as well as the services" [16] (p. 9). A key feature, which makes PFIs different from other PPPs, is that the private sector contractor also arranges finance for the project [16].

3.3. Espoused Rationale

There are two major types of argument in favour of PPPs: the first concerns fiscal policy and the need to reduce pressure on government budgets; the second promises improved value for money. The latter argument, which focuses on the total cost efficiency of PPPs, is the primary focus of this paper. Although the former argument is outside the scope of this paper, it also needs to be examined as it has been forwarded as the sole, or at least dominant, *raison d'être* of PPPs.

3.3.1. Through-Life Management as the Core of the Economic Rationale

The economic rationale, often called the value for money argument, is summarised by the UK Treasury: "PFI offers value for money benefits for certain complex investment projects, particularly through: a long-term focus on whole life costs; risk management expertise; and much greater certainty for the public sector that services will be delivered according to specified outputs. These benefits are derived from the PFI risk-sharing structure, whereby the risks associated with a project are borne by the party that can best manage those risks" [17] (p. 27).

Similar arguments are presented in the academic literature. Characteristics of PPPs that are claimed to synergise public and private strengths in a partnership agreement include sharing of tasks and responsibilities, risk sharing and incentive structures, private investment, life-cycle optimization, innovation through output specification, and long-term contractual partnerships [18]. By redistributing risk so that a single company is responsible for the through-life management of a facility, a strong incentive is created to make design and construction decisions which will have a positive impact on the cost and effectiveness of operation and maintenance [1,5,13]. Typically this means increased capital investment for saving operational costs. The creation of a life-cycle fund, or maintenance reserve account, is proposed as a key incentive mechanism. "This is a sum of money reserved for the replacing of elements, components and systems which have a life cycle duration that is shorter than the service concession period. The operation service provider enters into fixed base price contracts increased at agreed indices, and a maintenance reserve fund is incrementally built up to fund life cycle costs" [19] (p. 224).

Välilä [1] offers a useful summary on the economic rationale of PPP:

(1) engaging contractors more closely in the management of public sector projects, promotes levels of efficiency comparable to those pertaining in the private sector;
(2) a single contract for the production and service phases of infrastructure life-cycle enables these to be more closely integrated, facilitating design for (and learning from) use;
(3) risk is better apportioned.

Thus, there are three ideas: private ownership, bundling of different life-cycle stages and risk sharing. Here, we are concerned mainly with the second idea, that PPPs create the incentive for better through-life management through the long-term involvement of contractors and the creation of a single point of responsibility. As the UK Treasury has pointed out, the whole life aspects are the distinguishing feature of PFI among procurement forms [17]: "Unlike other procurement forms, PFI projects benefit from whole-life costing over 30 years, involving both construction and service delivery (. . .)".

However, the other ideas of the economic rationale are also relevant for through-life considerations. "Private sector efficiency" might certainly represent an aspiration to reduce costs at all points in the life-cycle: " . . . private owners have stronger incentives to look for cost savings than the managers of publicly-owned infrastructure assets" [20]. Better risk management focuses on risks that potentially would impact cost and/or value in some stage of the life-cycle. Thus, in resonance with [20], it can be argued that in practice the two other ideas merge into through-life management.

These arguments focus on the anticipated benefits of PPPs in comparison to traditional methods of procurement. However, it is noteworthy that it is not possible to find cases where such benefits would have been quantitatively predicted or targeted in policy documents. On the other hand, it has been pointed out that PPPs also have drawbacks, including: added transaction costs; long front-end preparation time; difficulties integrating public and private sector organisations; higher capital costs; and a lack of flexibility associated with long-term contracts [1,15,21]. Thus, any purported benefits have first to trade-off these drawbacks, for net benefits to emerge. This, of course, accentuates the need for evidence of manifest benefits.

We summarize the through-life management rationale, as widely presently in the governmental and scholarly literature, in the following hypothesis: *In creating a single point of responsibility and a*

long temporal involvement, the public private partnership model provides an effective incentive to implement through-life management.

3.3.2. Financial and Fiscal Motivation for PPPs

In many countries, the intrinsic PPP feature of deferred payment for an infrastructure investment has initially attracted the government to the use of this type of procurement. Taking this as the starting point, some scholars downplay the role and significance of through-life management (as well as other efficiency benefits) of PPPs. For example, Green [22] sees the topic of PFIs in the UK as highly politicized, and its origin in the need for off-balance sheet financing. He contends that (p. xv) " ... arguments in support of 'best practice' are invariably rhetorical devices which are mobilized by different interest groups in a continuous competition for power and influence." The argument for customer value is given as an illustration in terms of PFI (p. 337): "Thus, the value agenda remains strong in terms of its persuasive rhetoric, but rather less strong as a guide to pragmatic action. Perhaps its most useful role is to provide discursive resources for firms seeking to legitimize their role within the domain of PFI/PPP." In this kind of analysis, a weak realization of through-life management in PPPs would not come as a surprise, as it is not even especially targeted by the involved players but rather seen as an argument in a political debate.

However, there is a weakness to this approach, inasmuch as the rhetorical power of the argument, its ability to convince, must rely ultimately on its predictive power. If PPPs continually fail to deliver TLM, then the political leverage of its advocates will correspondingly be reduced.

The recognition of historical and contextual factors underlying such political evolution is also a hallmark of the discussed tradition. However, if we accept the significance of historical and contextual factors for PPPs [23,24], we must also be open to the idea that PPPs in other countries may have an origin and a context more in tune with the efficiency rationale than in the UK. Indeed, Chan and Cheung [25] found that when asked about the reasons for implementing PPP projects, Hong Kong and Australian practitioners rated issues related to improving the overall performance of public projects highly, whereas British practitioners rated financial elements, such as shortage of government funding and avoiding public investment restriction, highly.

Thus, the analysis of Green [22] on the UK experience cannot be generalised. There have been and will be situations where PPP is attractive, not for financial or fiscal reasons, but for the prospect of value for money, consisting of better through-life management, risk management and cost and time predictability. Thus, it is of interest to evaluate the realization of through life management (as well as other mentioned aspects, not focused in this paper).

4. Through-Life Management

The traditional approach to product realisation focuses on the handover of the product to its user. The need to successfully complete this transaction governs the design process, constituting the sole guarantee that requirements for use and maintenance are taken into account. TLM is intended to promote a more integrated and systematic inclusion of use and maintenance considerations, starting from design. Construction projects, particularly in the public sector, tend to be part of a much larger scheme for long term service delivery. These services can be as simple as highway maintenance, or as complex as the running of a modern hospital. Long term performance is dependent on effective management of the facility throughout its life-cycle. TLM is the integrated management of an artefact (in this case the built facility) throughout its whole life-cycle from conception to disposal. Thus, TLM encompasses business case, design, construction, maintenance, and demolition phases. TLM takes place in a dynamic environment: physical decay affects all technical systems and must be counteracted through maintenance and periodic overhaul; technical advance may lead to obsolescence; customer requirements change over time. Thus, maintenance will be essential, while modification or replacement may also be necessary.

The practical dimension of TLM can be illustrated through the case of the UK government, which has noted that maintenance and operational costs are greater than those of initial construction and which is promoting the following TLM initiatives: early engagement of end users during the design and construction process; commitment to a consideration of post-construction after-care by the design and construction team; post occupancy evaluation feedback to the design and construction team to capture lessons learnt and inform future projects; building information modelling to provide a fully populated data set to feed into computer aided facilities management, which will need to be maintained throughout the building life cycle [26].

4.1. Approaches to through-Life Management

There exist a plethora of TLM initiatives, including: (a) life cycle costing; (b) life cycle value; (c) life cycle management; (d) dynamic open box analysis; (e) capital value appreciation; and (f) product service [27]. These are briefly introduced as follows:

(a) The earliest approach involved the minimization of life cycle costs. Seminal initiatives taken by the US Department of Defense in the 1960s [28] shifted the focus from acquisition costs to the total cost of the product over its life cycle, thus covering the costs of R & D, design, production, operation, maintenance and disposal. The long life cycles of built environment products have made them a particular focus for life cycle costing (LCC) and an ISO standard for LCC analysis of buildings is currently under preparation. The basic principles are now widely known and agreed upon, but not commonly applied in practice, at least in Europe [29]. The approach has been extended to take into account environmental impacts through life cycle assessment (LCA), a predominant tool within industrial ecology [30]. LCA refers to "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" [31]. Total cost of ownership is a further related method for products with a shorter life time, such as cars and software [32]. As cost is uncertain in many aspects, it is imperative that any life cycle model incorporates the treatment of uncertainties [28].

(b) Life-cycle value includes the consideration of benefits in addition to costs, thus seeking to optimize the benefit/cost ratio over the life-cycle. The whole life value method [33,34], has been proposed in order to support investment decisions throughout the life of an infrastructure asset. This has led to much discussion of the ratios between the respective costs of producing, maintaining and operating buildings, with the implication that relatively small increases in production costs can leverage much larger savings in maintenance and operation, though reliable ratios remain elusive [35–37]. There is evidence of improved healthcare outcomes arising from improved hospital design [38,39]. Such considerations have also led to consideration of the subjective aspects of value and an emphasis on value exchanges between the wide range of stakeholder groups [34,40].

(c) The first two approaches are concerned with investment and design decisions. The next change of focus concerns the optimization of management processes throughout the whole life cycle and includes methods such as whole life systems engineering [41] and total asset management [42]. Other approaches, originating in marketing, strategy and product development and seen to promote this shift of focus include product service systems [43] and integrated solutions [44]. Process models, depicting life-cycle stages and their interactions, have emerged as a popular way of implementing through-life management. RIBA (Royal Institute of British Architects), CABE (Commission for Architecture in the Built Environment, OGC (Office of Government Commerce) and MOD (Ministry of Defence) have all produced their own models, though their efficacy is yet to be proven.

(d) Operations management, traditionally subscribing to a static view of the managerial situation [45], has also evolved a dynamic approach, in which the elimination of waste and continual learning and improvement are emphasised [46]. This can be seen as part of a broader movement away

from a simple view of production as an input-output relation, to one in which the temporal flow of materials and product are emphasised, along with the specification and delivery of value [47]. In production management terms, through-life management is about producing an artefact and then producing the services, which accompany it. In this conception, production is a continuous and developing flow of value generation among a variety of stakeholders [34], which calls for a lean life-cycle approach to management [48].

(e) Originating in sustainability economics and company valuation, an approach emphasising the preservation and increase of capital value has been proposed [49]. This capital approach can be implemented at different levels, ranging from global to a single company [50]. One important issue that arises is the identification of the different types of capital and the ways in which they can substitute for each other. Four such types are: the (physical) artefact itself; codified information about the artefact (in form of drawings, instruction manuals, maintenance history, *etc.*); uncodified knowledge and skills required for using and maintaining the artefact; and (influences on) the natural capital (depletion of minerals, pollution). A merit of this approach is that it brings hitherto disparate aspects of sustainability, information management and learning into the same conceptual framework.

(f) The product-service conception represents a further approach, in which the emphasis shifts from one-off transactional costing of a product (sale price) to the continual temporal cost of service (rental). This conceptual shift is seen as having particular benefits for environmental impact through continuous innovation supported [43]. Four possible product-service strategies are outlined, namely: selling a result, rather than a product (e.g., travel miles rather than roads); shared utilisation (e.g., renting office space by the hour); product-life extension services, including maintenance, upgrading and recycling; and demand side management, involving strategies to reduce demand (such as distributing low energy light bulbs) [51]. Important benefits for manufacturing and service companies, as well as the environment are identified [43], but it is also observed that considerable changes in social organization will be required in order to realise these.

4.2. Framework of Understanding of through-Life Management

There is no robust, unified conceptual foundation for analysing the above approaches. However, several elements of such a foundation can be identified by abstracting the core idea of each approach discussed (Table 2).

Table 2. Various perspectives of through-life management and their core ideas as indicated in literature.

Perspective	Core Idea
From investment cost to life cycle costs	From consideration of investment costs only, to minimization of life cycle costs of an artefact delivering an assumed level of benefits.
From cost to value	It is not enough to look at the costs, but the value provided by the artefact should also be taken into account.
From design focus to life cycle focus	From (optimization in) design to management throughout the whole life cycle.
From static black box to dynamic open box	From a static understanding of production to a dynamic flow view (with continuous focus on waste elimination and value maximisation through fostering learning and improvement).
From flows to capital	From looking at the flows of value and costs to a broader view that acknowledges the need to preserve and increase associated capital.
From considering product realisation to design of a business model	From managing at the level of product realisation only, to designing the business models where product realisation is embedded.

By slightly regrouping the core ideas in Table 2 and also extracting the treatment of uncertainty (inherent in all perspectives) as a category in itself, we tentatively propose the operational definition of through-life management as an approach, where:

(1) at each stage, activity and decision, the impacts on later stages, activities and decisions are taken into account in order to optimise through-life cost, value and material flows;
(2) unavoidable uncertainty is taken into consideration and counteracted when feasible;
(3) real asset capital is preserved and increased;
(4) managerial action is geared towards continuous improvement in terms of waste reduction and value creation;
(5) when feasible, the business model is redesigned to support continuous innovation towards through-life benefits.

This definition throws initial light on the relation between through-life management and public private partnerships, the latter being new business models used especially in infrastructure. A new integrated business model may be helpful, but it is not sufficient in itself—for a related argument see [52]. Creating the appropriate production system designs, operational methods and practices as well as methods and practices geared towards learning and improvement falls more properly into the realm of production management. Neither can a new business model be seen as necessary for through-life management as other principles in the definition above may be sufficient.

5. Do PPPs Deliver through-Life Management?

5.1. Evaluations in Prior Literature

In view of the recent calls for evidence based management and policy [53], it is pertinent to ask what evidence exists that PPPs are a form of infrastructure procurement that supports TLM.

Longitudinal case studies, where intended outcomes regarding TLM would have been followed up and assessed in light of actual experience at the project level, could not be found. Quantitative through life evaluations of PPP projects involving a large sample do exist, but they are relatively rare, obviously due to the difficulty of getting access to good quality longitudinal data both on PPP projects and comparative non-PPP projects. Table 3 presents two such evaluations (even here, both consider only a part of the life cycle) that throw light on the through life management aspects. No evidence for improved through-life management is visible in these studies.

Table 3. Evaluations of PPP schemes based on a large sample.

Reference	Sample	Main Results	Interpretation
RICS Construction and Property Conference [54]	395 secondary schools in England, from which 33 were identified as being PFI. The service costs over nine years were examined, covering core hard and soft FM services.	"... total facility services costs in PFI schools are higher (though not significantly) in six of the nine elapsed years. Total facility services costs are broadly similar over the nine elapsed years following renewal in rebuilt and refurbished schools."	The results do not provide evidence for reduced operational costs as a result of improved TLM.
European Investment Bank [55]	227 European road projects, of which 65 are PPPs. The *ex ante* (that is, budgeted) construction costs were examined.	"We estimate the *ex ante* cost of a PPP road to be, on average, 24% more expensive than a traditionally procured road, all other things equal. This estimate corresponds by and large to reported *ex post* cost overruns in traditionally procured public roads. To the extent that the two measures are representative, this suggests that the largest part of the *ex ante* construction cost difference originates from the transfer of construction risk. This, in turn, implies that other possible sources of higher PPP construction costs, including bundling, seem to be of second-order importance in the road sector."	The results do not provide evidence for increased construction costs due to TLM considerations.

With passing of time, the scientific literature on PPP as a procurement alternative has considerably grown, and a number of systematic reviews of literature have been made. A summary of reviews of literature is presented in Table 4 (all these reviews concern papers in peer-refereed academic journals). Empirically verified through-life benefits are notably absent from the reviews. Moreover, evidence from the wide array of literature pinpoints several unanswered questions and gaps in the knowledge, regarding both the PPP model in general and especially the realization of TLM.

Table 4. Systematic reviews of literature on PPP.

Reference	Sample	Main Findings
International Journal of Economics, Management and Accounting [56]	108 papers on PFI and PPP published in 26 selected public sector journals	"Concerning the VFM of PFI/PPP projects, there is no one study which found conclusive evidence that PFI/PPP has offered better VFM." "Pertaining to affordability and cost saving, most if not all studies reported evidence that was not in favour of PFI/PPP."
Public Management Review [57]	46 published journal articles focusing on PPPs in the health care sector	"although PPPs are used to address internationally emerging public health issues, questions as to their actual effectiveness, efficiency and convenience, still remain unanswered."
Facilities [58]	64 published articles from 32 journals	"More often than not, the studies were based on one or two stages of PFI projects rather than the whole life cycle of project: from feasibility to handover."
		" . . . there was still no absolute conclusion whether PFI deliver more VfM than traditional procurement approach"
Social Science and Medicine [2]	1400 publications from a wide range of disciplines over a 20 year period	Finds three themes in the literature, policy, practice and outcomes, with little research spanning across the three. Policy papers mainly focus on anticipated benefits, while practice papers highlight the disadvantages.
		Suggests a need for further research into: the strategically appropriate circumstances for creating PPPs; "the impact of incentive mechanisms and risk management procedures on health service performance throughout the extended project life-cycle"; and the fostering of environments conducive to learning across projects.

All in all, the conclusion must be that there is a clear gap between policy intentions and practical achievements regarding through life management in PPP projects. Remarkably, after more than 20 years of implementation, there is no clear supporting scientific evidence for PPPs in general, or the specific through-life benefits of the model.

5.2. Explorative Case Studies on through-Life Management

Detailed analyses of what actually happens in regard to TLM are clearly needed, in order to throw more light on the missing TLM benefits of PPPs. This section draws on the findings of two case studies carried out in the UK, which were undertaken to explore alternative approaches to TLM. It is not intended to present the full case studies here, but merely to highlight some relevant findings. The first focuses on a PFI to develop hospital infrastructure; the second, on a school building programme that adopted a non-PFI procurement route. The intention was, through in-depth interviewing and examination of documents, to capture the concerns and evaluations of programme participants. This kind of small-scale participatory evaluation approach can often reveal aspects overlooked in more formal studies with a larger scope [59,60]. The logic of these studies is both inductive and experimental [61]. Thus, they offer evidence that may be confirmed or contradicted by later studies, but also serve to initially evaluate the discussed rationale: in creating a single point of responsibility and a long temporal involvement, the public private partnership model provides an effective incentive to implement through-life management.

5.2.1. A Hospital Redevelopment

This study followed the course of a £160 million PFI project for the redevelopment of an existing NHS (state owned) hospital. The project was funded partly with public capital and partly through a PFI. The project had three aspects: the redesign of healthcare delivery services; the provision of new

facilities; and the refurbishment of some existing facilities. Emphasis was laid on the provision of new and refurbished facilities that supported the reconfigured service delivery. The privately funded element of the scheme was the design and provision of the newly built facilities.

Although the main aim of the research was to understand the process by which service design and building design can be integrated to facilitate improved service delivery performance through-life, from the perspective of those charged with the task, the data collected allowed also an evaluation from the through-life management perspective. Retrospective in-depth interviews were carried out with nine key participants. These were audio recorded and analysed by the team of three researchers, in order to map the design and procurement decision making process, identify facilitators and barriers to the integration of service and building design and establish how requirements for flexibility were addressed. In addition, project documents, including service descriptions and building plans, were consulted. Preliminary findings were validated and developed in a workshop with the original interviewees, where findings were presented and critically discussed [62,63].

The concept of the single point of control was found to be highly problematic. The provisions of the PFI scheme meant that designers could not be appointed until the outline business case (OBC) had been approved by the Department of Health. Since the OBC specifies service requirements as well as identifies key business outcomes, important decisions relating to the construction and use phases of the project had been taken before the design team could become involved in the project [62].

Furthermore, a stakeholder analysis revealed more than 60 categories of stakeholders involved in the project, several in multiple roles. Although several of the key players were partners in the PFI, it was realised that a distinction must be drawn between procurers and users, since the individuals directly involved in the procurement of a facility are rarely the same people who will be using it on a day to day basis. In order to capture user needs, over 30 user groups were involved in the design process. However, this did not prevent late changes in design requirements [62]. This contributed to a strong sentiment among interviewees that design for flexibility is perhaps more important than design for user needs. It was felt that in the field of medical care at least, practice is changing so fast and in such an unpredictable way that achieving a close fit to current practice was often wasted effort.

Finally, the project remained subject to the kind of consultant/contractor conflict over divergent interests, which is common in the construction industry. From time to time a crisis arose in which designs could not be agreed. A specialist "planner" was employed by the client to manage confrontation arising from these issues. This individual described himself as a "tank on the contractor's lawn". The persistence of such problems on a PFI project clearly casts doubt on the notion that a unity of purpose had been achieved.

Variation in the degree of involvement of participants, either working under sub-contract, or on a portfolio of projects within an organisation, also proved to be a problem. In this case study project, a particular designer was involved at an early stage, but unavailable at a later stage when required.

5.2.2. A New Build School Programme

The school study examined a £65 million local authority programme for building new primary schools, which were being delivered under a large-scale national capital investment programme. Unlike most of the school construction projects in the national programme, the local programme had no element of private finance, but relied mainly on state funding, with the addition of small pots of money from bodies such as the Regeneration funds and the National Lottery. Procurement was through a framework agreement with preferred designers and main contractors.

The purpose of the study was to evaluate the readiness for through-life management of the programme. A researcher was embedded in the local authority procurement team over a period of nine (9) months. Data collection was carried out through document review, eight interviews with project stakeholders (designers, project managers and local authority officials), observation of on-going projects meetings, a design festival, design reviews, daily design routines and a workshop as well as visits to completed school buildings.

The programme was carried out under the local authority's framework agreement, which established and regulated long term relationships with a number of preferred design and construction companies.

Project stakeholders included: head teachers and key members of the teaching staff of the schools (engaged through project briefing meetings, design reviews and post-occupancy evaluations); pupils (engaged through design festivals and post-occupancy evaluations), designers and builders (contracted through the framework agreement), local councillors and several local authority departments, including the local education authority (representing the commissioning client), the procurement team (local authority project managers) and members of the facilities management arm of the local authority. In addition, the programme was integrated into the wider regeneration plans for the areas where the schools were sited.

The involvement of pupils and staff at the design and post-occupancy stages was effective in allowing schools to specify the requirements for good learning spaces, providing an important benefit of TLM.

Problems in maintaining a single point of control were observed, centred around the devolution of decision making powers to the individual schools. This provided a point of control much closer to the end user than is usual, with the consequence that the local authority saw a reduction in its own ability to co-ordinate design and maintenance across the programme. A lack of expertise among head teachers and governors, now charged with these responsibilities, led to perceived inefficiencies. There was also an evident lack of knowledge among users about how to make best use of the new buildings, ventilation systems being a particular source of difficulty. However, schools whose buildings had been developed through the framework would often consult the procurement team for advice on these issues. In responding to these requests, the procurement team provided some degree of TLM continuity.

During the project briefing stage and the design development stage, a number of opportunities to capture data relating to TLM were observed. However, in the absence of a conscious and coherent process to facilitate TLM, it was not clear how this information would be incorporated into either future design or maintenance processes.

5.3. Discussion

The case studies both highlight the difficulties of creating a single point of control and maintaining it through the life-cycle of a built facility. The number and variety of stakeholder groups will always make the resolution of conflicting interests problematic and the intention to plan for the whole life-cycle of the facility increases the complexity of this problem. Both studies identified efforts to plan for the use phase of the life-cycle, through efforts to involve users in the design process. That this appeared to be less successful in the hospital study may be due more to the fast changing nature of the industry than to any deficiency in the procedures adopted.

However, it is clear that the PFI approach did little to create TLM incentives. The exclusion of designers from the early planning stages and the continuing organisational divide between the SPV (Special Purpose Vehicle) and the client organisation, meant that the SPV was focused on the costs of construction and maintenance, with little motivation to consider the cost or convenience of using the building. By shifting the emphasis from the profitability of single projects to the profitability of the parties' involvement in the programme as a whole, the Framework Agreement adopted on the school programme seems to have been more effective at providing incentives for through life management than the PFI. In general, the Framework Agreement showed a more consistent attempt at TLM, with the administration of POEs (Post Occupancy Evaluations) and a strong focus on maintenance issues by the procurement team.

Ultimately, neither case reveals a strongly systematic approach to TLM, raising the possibility that successful implementation may depend less on tinkering with contractual incentives and more on an effort to educate stakeholders in TLM concepts and procedures. In relation to the various perspectives

of TLM presented in Table 2, the case studies show that there is some movement towards addressing issues related to life-cycle value, but they are far from getting to a state of actually designing the whole life-cycle. In the schools case, this is evidenced in the consideration given to how maintenance services were to be administered, driven by the devolution of budgetary powers to the schools. In the hospital case such considerations were less developed, but there was evidence that near-future developments in service provision were seen as a vital consideration. However, even addressing life-cycle value presents particular problems for a hospital, since technology and demand are highly unpredictable and fast changing, as compared with the rate of infrastructure development. Attempting to upgrade a Victorian hospital to modern service requirements, which themselves are undergoing constant re-appraisal, leaves a limited scope for long term future planning.

Remarkably, the case studies challenge thus every part of the rationale for TLM in PPP: starting from the existence of a single point of control and ending to the organizational ability to implement TLM. A null hypothesis emerges: that all parts of the rationale are prone to failing.

6. Evaluation of the Espoused Rationale Regarding through-Life Management

Guided by the findings from the case studies, the realization of the espoused rationale for through-life management in PPPs is evaluated next, based on empirical and theoretical literature.

6.1. Do PPPs Create a Single Point of Responsibility?

The case studies highlight the difficulties in creating a single point of responsibility. There is little in the literature that directly addresses this issue. However, Diggs' and Roman's study [64] highlights the difficulties of maintaining accountability in these types of projects. This is unsurprising, as governance through a single point of control involves facing a problem that has long been recognised in organisation theory, the difficulty of enforcing centrally made decisions [65,66] and the negative consequences for flexibility in doing so [67,68]. The situation is particularly aggravated in the built environment where the 'fragmented' nature of the industry has long been a source of comment [69]. Particular sources of difficulty are: the allocation of risk when the party most able to manage it is the least able to carry it; and the development of collaboration under the governance of stringent conventional contracts [5]. Collaboration is arguably based on trust; however, research indicates that interpersonal relational mechanisms based on trust, which provide complementary governance mechanisms to contractual mechanisms, develop incrementally and are fragile [70].

Roehrich and Caldwell [71] comment that as a response to the need to be competitive, the solutions provider anyway "unbundles" the bundle of integrated solutions by creating sub-units to handle distinct phases. They describe the impact of this as follows: "The vertical disintegration of the contractor appears to defeat taking a holistic through-life approach by re-creating intra-organizational silos. However, the most significant effect of this unbundling into subunits on innovation may be in the barriers it raises to integration and alignment between buyer and supplier."

Thus, the case that PPPs create a single point of control is faced both by theoretical difficulties and unpromising initial research findings. As Burgoyne and Jackson [72] have observed, the governance of PPPs might be better represented as a contested arena, rather than a single point of control. It is also interestingly to note that in environmental governance, similar challenges of integrating shared interests, knowledge and values have necessitated the development and fostering of novel adaptive and collaborative management processes [73,74].

6.2. Can a Single Point of Responsibility be Maintained throughout the Life-Cycle?

Notwithstanding the difficulties of creating a single point of responsibility, a further problem is the maintenance of such a centre of control over the lifetime of the infrastructure, relying as it does on the sustained commitment of the various project participants. Among the obstacles to be overcome are discontinuities created by stakeholders entering and leaving the project.

Participation in a PPP project requires long-term commitment. However, as observed regarding alliances in general, the time-orientation of companies varies and companies with a short time orientation are attracted to partner opportunism [75]. In the case of PPPs, long-term commitment from contractors often fails to occur. They will often sell on their stake, sometimes before the building project is completed [3]. Variation in the degree of involvement of participants working under sub-contract is a particular problem. Even where the different phases of private participation in the life-cycle have been brought under the governance of a single organisation, this does not guarantee the formation of attitudes and/or relationships that would lead to life-cycle integration [76,77]. A constant turnover of staff, and particularly regarding the project manager role [78], is an additional related hindering factor. Clients may also lack commitment to what effectively becomes a commercial enterprise [13]. Diggs and Roman [64] conclude that anything other than temporary PPP arrangements are only possible "under rigid constraints". Sometimes the reasons for discontinuities are perverse in the PPP context. An Australian study [77] of a PPP, delivering social infrastructure in multiple locations, note the frequent exclusion of facilities management considerations from the design phase, in order to reduce the cost of hiring consultants.

Empirical studies paint a critical picture with regard to the ability to maintain the single point of control. In resonance with the study of Roehrich and Caldwell [71], a study of seven British schemes [79] argues that PFI "may shift responsibility for coordinating planning, design, construction, and operation from public bodies to the private sector, without creating any more integration between the different project delivery stages".

Thus, there are several different mechanisms through which continuously maintaining a single point of responsibility throughout the life-cycle may be at risk.

6.3. Providing Appropriate Incentives

Do PPPs provide appropriate incentives? This may not be the case if there are competing incentives available, through which the involved organizations may realize their objectives, or if there are implicit assumptions, underlying the functioning of the incentives, which do not realize in practice, or if the incentives are diluted or vanish for other reasons.

In the context of a PPP project, such competing incentives may include selling the stakes to another party, manipulation of the price between the selection of the PPP coalition and the signing of the contract, and trying to reduce costs through lower quality. Thus, the minimization of the life cycle cost does not necessarily carry such weight as an incentive as could be expected. An example is provided through study of 52 secondary schools completed between January 2000 and September 2006 [80], which found a strong relationship between PPP procurement and inferior design. Hoppe and Schmitz [81] have modelled the incentive for PPP contractors to secretly amass restricted knowledge about the facility, from which they can then profit. In turn, public partner opportunism is forwarded as a factor carrying critical effect on partnership outcomes [82].

Are then the underlying assumptions of incentives valid? The single point of control conception is itself based on an economic theory of motivation, which does not address the complexity of competing interests and incentives that operate in PPP organisations.

The incentives delivered through novel procurement forms are mediated by diverse goal orientations and power differentials among project participants, and shaped by the conservative effects of culture [83]. Incentive schemes do not work on an individual level in partnership oriented construction projects, as is often assumed. Rather, "strong moral commitment, shared cultural values and close personal identification with each others goals" have a stronger influence on individual behaviour than financial incentives, which, far from being passed on, are sometimes actively hidden from individuals working at site level [84]. Thus, the effects of incentives are dependent on such factors as: the effect they have on community oriented behaviour; the message they convey about client intentions; and the extent to which they are perceived to undermine individual autonomy [85].

Regarding other reasons for incentive dilution or loss, the study of Rintala [86] is illuminating. He could not find a single whole life cost driven design solution in the heating and ventilation design solutions of the two PFI case study projects. In the first case, the client retained the energy consumption risk as it depended on the volume of activity in the facility. Thus, the consortium had no incentive to implement solutions to minimize operational costs. In the other case, the private partner was responsible for energy consumption above a certain standard if it resulted from the design, construction and operation of the building. However, the baseline was not very ambitious due to lack of historical data. Although the SPV had thus a certain incentive, it was counterbalanced by an adverse position of the financier and the contractor.

There is therefore ground for supposing that the incentive to deliver improvements in through life management is weakened for several reasons: first, there are competing incentives, second, social, cultural, and organizational issues that filter down the force of incentives, and third, contextual decisions or conditions may interfere with the incentive.

6.4. Is There Readiness for Implementation of Through-Life Management?

Through-life management is a relatively novel approach. Thus, even if the theoretical preconditions for TLM discussed above were in place, its implementation could fail, or remain partial due to a failure to acknowledge this novelty and to engage with the necessary learning, as observed in the case studies. Here, we adopt the key aspects from the definition of through-life management developed above, in order to assess the achieved level of understanding and the learning still required to implement TLM in PPPs.

6.4.1. Impacts on Later Stages Taken into Account

There is only partial evidence that the whole life cycle of the infrastructure product is systematically considered. Although quantity surveyors in PFI projects report that they generally consider life-cycle options, they admit that in certain circumstances the decision is made based on the lowest capital cost [87]. The list of such circumstances covers not fewer than eleven situations, ranging from tight construction budgets to lack of detailed information about the various options due to lack of access to the people who prepared the original estimates. The cited research found that such failure to consider life cycle cost had significant financial risk implication for the facilities management contractor of a PFI. Generally regarding life-cycle costing, the lack of understanding of the technique and the absence of a standardized methodology have been found to be key limiting factors to wider implementation [88].

Lack of communication between parties and stages may provide another bottleneck for life cycle consideration. More communication was found necessary between client, project company and contractors during design development [3]; and also between contractors and their facilities management arms [76].

Thus, important obstacles remain to temporal integration in PPPs. Decisions continue to be made as if the project was constituted of a series of discrete stages.

6.4.2. Uncertainty Considered and Counteracted

There is evidence that contractors have difficulty predicting through-life costs [89] and revenues [21]. New skills and methods for assembling and analysing through-life data are required.

6.4.3. Capital Preserved and Increased

The contractually specified maintenance level in PPPs is probably instrumental for conserving capital, at least empirical studies do not provide grounds for contrary arguments. However, as PFIs typically involve the hand-back of assets after 30 years, there is little incentive to design and plan for asset appreciation beyond that time period. Moreover, as the use of PPP arrangements grew rapidly in the 1990s (especially in the UK), the problem of how to master the hand-back and how to organize

maintenance in the continuation without losing the accumulated know-how will become an acute issue for client organizations in the coming years.

6.4.4. Continuous Improvement Pursued

Little evidence has been found of a conscious orientation to continuous improvement. Rather than promoting technical improvement, solutions centre on improving the management of relationships [90,91]. However, a recent UK Treasury report finds a year on year improvement in the achievement of contractual specifications and makes proposals for further learning [17]. Some of the necessary learning concerns technical features of the types of projects being undertaken which would be salient whatever procurement route was adopted.

6.4.5. Business Model Supporting Continuous Innovation

Although there is some evidence of additional innovation in PPP projects, it is not self-evident that incentives alone can promote innovation as this is dependent upon other factors such as "reliable information, sufficient time, degree of inclination" [3]. Indeed, in a study of seven British schemes, Barlow and Köberle-Gaise [79] argue that PFI has not been supportive of innovation. This conclusion is supported by Eaton, Akbiyikli and Dickinson [92], who found significant theoretical impediments to innovation, which appeared to outweigh stimulants in three out of four cases studied. It was also found that the PFI project delivery model to support sustainable energy innovation is weakened by the limited clarity of the sustainable energy requirement; ineffective multidisciplinary communication and collaboration; and ineffective client/user-producer communication and collaboration [93]. While the relative failure of PPP projects to demonstrate innovation probably has multiple causes, it seems that one significant cause is the missing ability of the involved parties to create and use the new space for innovation allowed by the integrated model.

6.4.6. Summary

Empirical insights from literature tend to indicate that the parties in PPP projects have only very partially engaged in the necessary learning, development and adoption of frameworks and methods towards through-life management.

6.5. Synthesis of the Evaluation of the Rationale

All in all, though there are some pieces of evidence of through-life management in PPP projects, they are insufficient to justify a belief that the PPP model is adequate in itself to ensure implementation. The weaknesses of the received rationale are summarized in Table 5.

Table 5. The rationale of public private partnerships regarding through-life management, and its weaknesses.

Rationale	Weaknesses
In creating a single point of responsibility	Fragmentation typically remains, taking new forms.
and a long temporal involvement,	Involvement is often short term.
the public private partnership model provides an effective incentive	Competing incentives exist. Incentives do not reach all parties or get diluted.
to implement through-life management.	The organizational learning required by TLM is often neglected. The necessary ability regarding TLM is often not in place.

7. Discussion

Do PPPs for infrastructure promote effective TLM? It must be concluded that they do not. Little evidence for cogent outcomes regarding TLM benefits can be found, and the reasoning underlying the claim of TLM benefits arguably suffers from serious weaknesses.

Given the time-frame in which the PPP model has already been used, these weaknesses in its reasoning regarding TLM might be seen as puzzling. How is it that, the TLM benefits having been continuously publicized, nobody has cared to analyse whether the incentive structure does its assumed job, or whether the PPP vehicles are ready to implement TLM? Without claiming a definitive treatment, we pinpoint to a number of possible root causes.

Regarding the lack of attention to the weaknesses of the incentive structure, there are two possible root causes. Firstly, if PPPs have been implemented for other reasons than TLM, as Green [22] is claiming, then indeed TLM remains in the area of empty rhetoric. In this case, the PPP parties do not have any real interest or need to analyse and deal with incentives towards TLM as they occur in such projects. Secondly, there may be weaknesses in the economic reasoning about the bundling of life-cycle stages, and the optimal allocation of resources over the life-cycle, to which it allegedly leads. Here, we need to scrutinize the nature of economic theory itself. Economics originally borrowed its approach from physics, which had axiomatic starting points [94]. Accordingly, the idea of economic incentives is an axiomatic starting point, and it would be incompatible with this assumption to start analysing whether the economic incentives provided actually work. Moreover, the economic theory lacks an analysis of production, treating it as a black box [95]. TLM is intimately concerned with production. For the production of infrastructure and delivery of intended service through it, a complex system consisting of an organization, a production system, control and learning mechanisms, *etc.*, has to be set up and operated. It is evident that the intended rationale gets easily diluted or even lost in this endeavour. While the process is treated as a black box, this dilution remains invisible. (This argument aligns with the conceptual observation made above in connection to the definition of TLM: a new business model enables TLM but it cannot be seen as a sufficient or necessary condition for it.)

Regarding the difficulties of implementing TLM as such, there are similarly two main hypotheses. Firstly, it can be thought that the question is about failed change management: the targeted state is well-known, and consists of the use of new methods and tools, but it has been difficult to realize that change due to organizational inertia. Secondly and, perhaps more importantly, it can be argued that TLM also requires new underlying theories and new behaviours, that is, cultural and cognitive change [96–98], which is much more difficult to achieve than just the implementation of new methods and tools.

What are the implications of the findings reported in this paper for practice and research? The overriding conclusion is that TLM benefits should not be considered as a self-evident and proven merit of the PPP method in policy considerations. However, the argument regarding the growing attractiveness of PPPs in European healthcare [99] given the shortage of public capital, in spite of their mixed results, is revealing. As it can be expected that the PPP method will, mainly for fiscal reasons, be used in the future, the crucial question is whether, and if so how, the weaknesses of TLM rationale in PPP projects can be eliminated.

It is fair to note that there has already been an evolutionary and positive change, and adjustments of the contractual forms related to PPP schemes. In the UK, for instance, parliamentary hearings [100,101] often provide a stimulus for development. Nevertheless, considerable further change is needed in order to overcome the problems of unity, continuity and incentive flow-down in PPP schemes. It seems reasonable to propose that PPPs could more effectively deliver TLM if explicit requirements were built into the contractual model. At a minimum, these would include more carefully designed incentive structures and a requirement for continuous reporting on the outcomes of TLM. In addition, the bidding stage, the different bidders could, for example, be asked to demonstrate how they intend to organize transparent and effective TLM, to indicate their track record of TLM in prior projects, and to give evidence on the aligned time orientation in the bidding coalition.

Given the uncertainty and lack of evidence that surround the achievement of TLM in PPPs, we recommend a design science approach [102,103] to explicitly address and redesign the mechanisms through which TLM related objectives are intended to be realized. This of course requires that the "black box" of production (that is, first the design and construction of the facility and then the

production of services based on it) is opened and treated in detail. However, this also implies the admission that any new type of contractual or organizational arrangement is necessarily tentative in nature. It also requires the careful and impartial evaluation of project outcomes against their targeted objectives.

However, even if the incentives for TLM were perfect, the question would remain: how can TLM best be promoted? It is not a mature procedure but still under development. Given the still low level of experience, an approach stressing learning and continuous improvement seems appropriate. Also the question of which contractual and organizational forms best support it is still an open one.

In this context, it is also opportune to remember that for the PPP project realization route to succeed in the long run, it cannot be seen to be clearly less efficient than competing alternatives—some of which indeed show more overall promise. For example, systemic application of target value design, embedded contractually in integrated project delivery arrangements, has been found to lead to significant improvement of project performance, especially to on average 15% project cost reduction [104]. Interestingly, target value design seems to be strong in the areas where PPP was found to be weak; thus it has an explicit and transparent incentive structure and it is used in a context where there is ability and readiness to use new managerial methods. Although target value design has mostly been used in relation to capital costs, it is argued to be applicable also to life-cycle costs [105]. The framework agreement approach examined in the school building programme case study also shows some promise.

Finally, the findings pinpoint some new topics for future research. Already there are many obvious research needs related to the practical implications discussed above. Beyond that, analogous to this research, the realization of other elements of the value for money argument in relation to PPP, especially improved risk management and cost and time predictability, attract critical evaluation. Furthermore, the identified drawbacks of PPP deserve increased scholarly attention.

8. Conclusions

The paper provides three contributions to knowledge; all of these can also be practically applied to inform better policy-making and help to achieve more successful schemes.

First, an operational definition of through-life management, integrating the various extant but partial approaches, is presented. Arguably, this definition better captures the many facets of the complex phenomenon of through-life management than prior, narrower definitions.

Second, a synthesis is provided of the scientific literature on the gap between espoused intentions and achieved outcomes of through-life management in PPP projects. Plainly, there is no clear supporting scientific evidence in support of PPPs regarding the through-life management benefits of the model. Although this gap has become visible in many governmental inquiries and individual studies, the full weight of existing scientific evidence has not previously been brought forward.

Third, an overview on the varied reasons for the mentioned gap is presented. In order to address this issue, the reasoning connecting PPPs and TLM is first defined: in creating a single point of responsibility and a long temporal involvement, the PPP model provides an effective incentive to implement TLM. Four main problems in this reasoning are found to explain the gap: fragmentation is factually prevailing; not all parties in PPPs intend to have a long time commitment to the project; there may be competing incentives for some parties; and the effort to achieve the change and learning necessary for TLM may be neglected. Prior literature has indicated individual reasons but a synthesis has been missing.

It is concluded that for TLM benefits to be achieved, the PPP model needs to be redesigned to secure the realization of the intended incentives for TLM and to explicitly incorporate the principles and mechanisms of TLM at the level of production system design, control and improvement.

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