The Value of Public-Private Partnerships in Infrastructure[1]

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Abstract: This paper makes three claims. First, in contrast to Public-Private Partnerships (PPP) in many other industries, infrastructure contracts can be conditioned on the delivery of roads and railways of appropriate user quality. This eliminates one of the concerns in the literature of the welfare properties of PPPs. Second, the bundling of investment and maintenance into one single rather than several separate contracts may provide a way to bypass rigidities and contract incompleteness in PPP contracts. Third, having a private concessionaire organising the funding of a PPP project's investment costs may increase financing costs. This is, however, balanced by the fact that it also enhances the agent's commitment in long-term incomplete contracts. Taken together, these conclusions point to the possibility of using PPP as an instrument for improving the construction industry's dismal productivity performance.

Keywords: PPP projects, asymmetric and incomplete contracting, risk, commitment.

JEL code: D8, L9

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1. Introduction

Large infrastructure investment projects are costly to build, while subsequent spending on the maintenance and operation of the facility is comparatively small. In view of their often long service-life, the aggregate (present) value of spending on maintenance may still be substantial. Furthermore, there is a link between the two cost components in that more spent during the construction phase to create an asset with higher quality may save on subsequent maintenance costs, and vice versa. In addition, the quality of the road or railway may affect future users, since an investment that has been built to a high standard will have greater chances to deliver high-quality services.

Infrastructure investment shares these qualities with costly projects in several other sectors of the economy. Once built, however, a road, railway, airport or port has low opportunity costs, i.e. it has no value for uses other than it is built for. In combination with other market failure problems, this means that the provision of infrastructure services is typically a responsibility of the public rather than the private sector. But although the public sector is ultimately responsible for service delivery, only a few countries still use in-house resources to build new and maintain existing infrastructure. Rather, these services are provided by the private sector after a process of competitive procurement.

The construction industry as an aggregate, including infrastructure as well as housing and industry construction, has a dismal performance in productivity terms. In Sweden, the labour productivity of the production industry more than tripled between 1980 and 2007, and almost doubled for industry at large, while labour productivity in construction grew by a mere 23 percent (Swedish national accounts data available at www.konj.se). A recent EU project has produced a comprehensive database to facilitate an analysis of total factor productivity. Data available at www.euklems.net shows that industry production increased by 10 percent in Sweden, and by 2 percent in ten of the EU's original member countries between 1994 and 2005. Output in the construction industry dropped by around 6 percent in both Sweden and the peer EU countries in the same time period. In fact, total factor

productivity in construction actually decreased during substantial parts of this period. Productivity performance is poor in this part of the industry irrespective of what measure is used.

There are many possible reasons for this development. This paper suggests the hypothesis that the industry's contracting practices provide poor scope for innovation and cost savings. There is no obvious way to test this hypothesis based on aggregate data. Rather, the paper relies on a description of the standard way in which contracts between a public sector principal and a private sector agent for infrastructure investment and maintenance are designed. In this way a framework is built to compare traditional procurement with the increasingly common use of Public Private Partnerships (PPP) in infrastructure provision. PPP is here defined as a contract where the agent raises the capital needed to undertake a bundled project and retains control over it for a number of years after completion, whereafter it is handed over to the procuring agency; bundling refers to the joint procurement of construction and operations.

While PPPs over the years have been, and sometimes still are, pursued as a source of additional financing of infrastructure, most economists are not in favour of this aim. The purpose of this paper is to argue that the motive for the new contracting format rather should be its potential as a mechanism to enhance productive efficiency. In particular, the paper demonstrates that a standard qualification regarding the efficiency potential of PPP projects – that bundling of construction and maintenance may jeopardise service quality – is not a major issue for infrastructure projects. This is so since both ex ante specification and ex post monitoring of service quality are feasible. The merits of PPPs should therefore be seen against a background of the shortcomings of the standard approach for unbundled procurement, in particular the rigidities generated by their command-and-control nature.

The paper maintains that the focus in considering whether PPPs should be used for infrastructure production should be directed towards issues related to risk allocation and the inevitable challenges posed by incomplete contracts for long periods of time. It also demonstrated that the use of private financing in PPP's may serve as a device for disciplining the private partner into renegotiating

contracts on an equal footing with the principal in case of external shocks. In particular, this will cap the contractor's incentives to shirk when it comes to construction quality in the hope of winning favours in subsequent renegotiations.

Section 2 summarises some insights from the contracting literature. Section 3 establishes the welfare properties of the optimal provision of infrastructure services, thus providing substance to the issue of service quality and the necessity to take into account user costs in the optimal design and maintenance of the finalised project. Section 4 describes four different ways to contract for infrastructure investment and maintenance, with the standard procurement model as one extreme and PPP as the other. Section 5 concludes the paper. Examples from road projects and one railway project will be used, but the analysis may equally well be generalised to apply to other infrastructure projects. The wider applicability of the conclusions hinges on the possibility of measuring and monitoring the quality of future service delivery in other applications.

2. Literature review

The literature on Public Private Partnerships is growing fast. Iossa & Martimort (2008) seek to analyse PPPs from the perspective of asymmetric and incomplete information, at the same time as they summarise previous literature. Iossa et al. (2007) provide a best practice manual for a range of design aspects. The purpose of this review is rather more modest than these previous papers in that focus is on some aspects of the literature with obvious implications for the paper.

A common denominator of the complete contracting literature, summarised for instance in Laffont & Tirole (1993), is the focus on the choice between fixed price and cost plus contracts and the implications for incentives and profit sharing. Incentives are best provided – and high powered – if the agent bears a high fraction of the project costs (C). A fixed price contract has this quality but makes it feasible for the firm to make a rent at the same time. Reimbursing the firm's cost by means of a cost plus contract limits its rent but provides poor incentives for cost savings. The standard moral hazard model suggests an incentive contract to trade-off these aspects, with reimbursement (t)

being $t = \alpha - \beta C$, where a is a fixed remuneration, $0 \leq \beta \leq 1$ the cost sharing parameter and C (observable) costs. The design of the remuneration is thus one means for balancing profits and providing incentives for cost minimisation. In addition, the granting of a contract after a bidding contest works to alleviate the adverse selection problem. The bidder winning the contest is thus the best type among the contestants.

In addition to the incentive-profits' trade-off, the power of contracts affects risk; the more the risk of negative cost realisations that a contractor has to accept, the larger the required remuneration will be. A fixed price contract leaves the entire risk with the contractor while the procurer bears all the risk of a cost plus contract. A bid for a specific project remunerated at a fixed price would – ceteris paribus – be higher than if cost plus remuneration were used in order to compensate the bidder, not only for the possibility of negative cost realisations but also for the very willingness to bear this risk.

Chapter 7 in Milgrom and Roberts (1993) summarises the incentive-intensity principle. Applied to the procurement context, the remuneration for an assignment should be closer to a fixed price contract the more discretion the agent can be given in doing the job, including the pace of work, the methods to use, etc. In addition, the more the agent can do to reduce the expected costs of a project, the higher the power in the contract should be. If the agent can hedge ex ante, or take precautionary action in order to reduce the consequences of negative realisations, it is therefore a reason to provide incentives for doing so. Moreover, differences with respect to risk aversion between agents as well as the costs of quality monitoring should affect the power of the contract.

A PPP combines two stages of the process towards delivery of infrastructure services, i.e. investment and the subsequent maintenance of a finalised project. The common view on the pros and cons of bundling has been summarised in the following way:

'(B)y "bundling" construction and operations, they induce the developer to internalize cost reductions at the operations stage that are brought about by investment at the development stage. But, by the

same token, bundling … may encourage choices that reduce future costs at the expense of service quality.' (Maskin & Tirole 2006, p. 2.)

Inefficiencies arise under incomplete contracting conditions, not primarily because one party to a contract ex ante knows more about matters of pertinence for the contract's execution than the other. Rather, the problem is that both parties have problems foreseeing and contracting the uncertain future. In such situations, ownership may matter since the owner of an asset or firm can make all decisions concerning the asset or firm that are not included in the initial contract. All parties to the contract are aware of who has this residual control.

Applied to the PPP context, Hart (2003) concludes that bundling may be welfare-enhancing if there are good performance measures to reward or penalise the bidder. If not, it may be beneficial to buy construction services from one provider and to provide detailed instructions about the quality to be provided. Once construction is completed, the principal procures operations and maintenance, assigning the contract(s) to the same or to some other agent. This reduces the risk of cost savings coming at the price of inferior quality for the final users during the investment phase. Conclusions are thus similar to the complete but asymmetric information context.

Bajari & Tadelis (2001) analyse the choice between fixed price and cost plus contracts based on the empirical observation that the cost sharing parameter β in reality is zero or one; incentive contracts are rare. They argue that the ex ante information asymmetry may be small but that contracts often have to be renegotiated, for instance due to unexpected changes in the preconditions for a project. An advantage of the cost plus contract is that it ex ante presupposes day-to-day communication between the contracting parties, making it easier to adjust the contract to the precise situation at hand when a project is to be implemented. The authors demonstrate that the contracting issue is more concerned with how the parties adapt to the actual situation at hand after the contract has been signed rather than the possibility of ex ante information rents. Safeguarding the competitive pressure, the financial

situation of the winning bidder and the winner's track record from previous contracts may therefore be more important than the value of ß for the outcome of a deal.

This perspective is further developed in Bajari et al (2007) where the incompleteness of the contracts is in focus. Final costs may be higher than the winning bid and the realisation of the contract may also result in substantial costs of adaptation and renegotiation. They analyse a database comprising road construction contracts in California and demonstrate that adaptation costs may account for about ten percent of the winning bid.

3. The Generic Welfare Maximisation Problem

The generic features of an infrastructure investment problem provide the framework for the understanding of issues in the contracting of construction and maintenance. The investment problem is concerned with the establishment of the optimal capacity K and usage N of a certain road, given that optimal road pricing is implemented.[2] In equation (1), social welfare (S) is the difference between benefits and costs associated with the project. Benefits are represented by $D(\bullet)$, the inverse demand for trips, which at the margin coincides with the willingness to pay for using a road. f is the toll – if any – to be paid for using the facilities and the restriction ascertains that supply is equal to demand in equilibrium.

Costs comprise three components: The first refers to (generalised) costs for N identical users each with cost function $c_u = c_u(N,K)$, which refers to time, vehicle operating costs etc of using a certain road. The second component represents costs for third parties, $c_3 = c_3(N)$. This captures the possibility that traffic is noisy or generates other external hazards for residents along the road or for society at large. The third is the cost of providing capacity, $C_{cap} = C_{cap}(N,K)$. $K=1$ if the road is built, and zero otherwise. All costs are related to the road's traffic (N). Benefits and costs are discounted present values.

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[2] The model in this section is a recycled version of Verhoef (2005).

$$Max_{N,K} S = \int_0^N D(n)dn - N * c_u(N,K) - c_3(N) - C_{cap}(N,K) \qquad (1)$$

$$s.t. \quad C_u + C_3 + C_{cap} + \varphi - D(\cdot) = 0$$

Assume now that a decision to build the road has been taken, meaning that $K=1$ and can be suppressed. The tradeoffs in the construction and maintenance of this road, given a certain projection $\hat{N}$ for current and future demand, is captured by (2), where overall costs for society are minimised by choosing an appropriate quality (q).[3] This refers to the standard of the infrastructure that is to be built, incorporating both its capacity (more lanes etc. mean lower user costs) as well as surface smoothness, safety performance etc. (3) is the optimality condition where superscripts denote the partial derivative.

$$Min_q C = N * c_u(\hat{N},q) + c_3(\hat{N},q) + C_{cap}(\hat{N},q) \qquad (2)$$

$$\hat{N} * c_u^q + c_3^q + C_{cap}^q = 0 \qquad (3)$$

Capacity costs are made up of the resources allocated both for building the facility (k) and for subsequent maintenance (c); $C_{cap}(\hat{N},q) = k(\hat{N},q) + c(\hat{N},q)$. Construction costs increase in quality since a better road – i.e. straighter and wider – is more expensive to build than a more curvy and narrow road; $k^q \geq 0$. But a thicker sub-structure may reduce future maintenance spending so that $c^q \leq 0$, implying that there is an externality between construction and maintenance. The optimum quality from the perspective of direct financial costs – $\hat{q}$ – is thus when $k^q = c^q$. Figure 1 illustrates this for reasonable assumptions of second derivatives.

But the better the quality of a road, i.e. the smoother and more convenient a trip, the lower the (generalised) user costs; $c_u^q < 0$. Moreover, it is feasible to build and maintain the road in ways that

reduce third party costs. Noise can be mitigated by using less noisy pavements. Emissions by way of

particles from studded tires can be curbed by using pavements that are harder and emit fewer particles.

Costly extra spending on quality may therefore reduce third-party costs, i.e. $c_3^q < 0$.
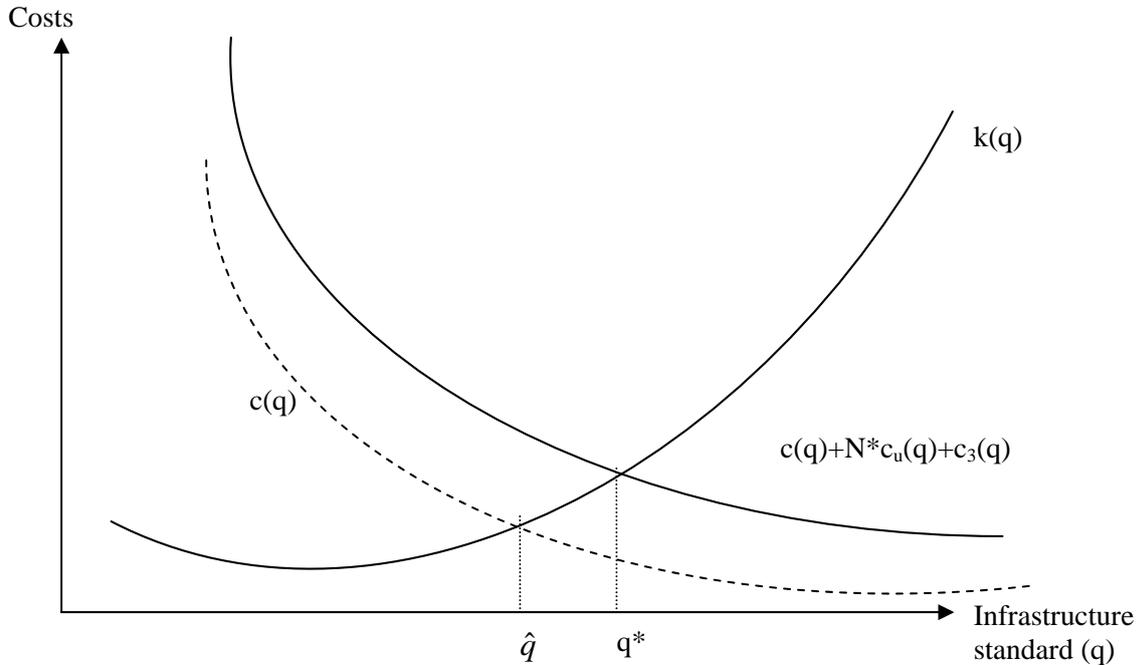

Figure 1: Balancing construction and maintenance costs against costs for users and third parties.

Social efficiency, illustrated as q^* in Figure 1, calls for balancing construction costs against the

implications of quality choice not only for subsequent maintenance, but also with respect to its impact

for users and third parties. The socially efficient quality is therefore higher than it would be if the

facility were built with the objective of minimising financial costs only, i.e. $q^* > \hat{q}$. The concern in the

literature has been with the measurement and control of quality in order to implement q^*. The next

section reviews four ways to implement this policy.

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[3] Ideally, optimisation should simultaneously consider different design and quality parameters as part of the decision on whether a project is to be built. In practice, and to focus here on the quality issue, these steps are often taken in sequence.

4. Four ways to deliver services

For many years and in most countries, infrastructure services have been provided using in-house resources, both to maintain existing infrastructure and partially or fully to build new infrastructure. This is a command-and-control strategy where the policy is implemented by detailed instructions to the agency's own staff. The cornerstone of this strategy is a set of manuals with detailed technical instructions on how to build and maintain a road, a bridge, a tunnel etc. Manuals and construction norms represent the accumulated experiences of design and maintenance strategies, and provide state-of-the-art instructions for how roads are to be built under various external conditions. The manuals may be said to represent the tangible manifestation of the tradeoffs represented by eq. (3) above.

In order to enhance productive efficiency, the common practice for implementation has shifted towards competitive procurement. This section will specify four different approaches for designing the procurement process and the subsequent contract(s) between a representative of the public sector and one or more commercial provider(s) of construction and maintenance services. The purpose is to pinpoint how these models differ and to establish their efficiency qualities. Engineers refer to traditional contracting as Design-Bid-Build (DBB), presented in section 4.1. Another three alternative models are found in section 4.2 (Design-Build), 4.3 (performance contracting) and 4.4 (Public-Private Partnerships).

This description is supported by the time line drawn in figure 2, which illustrates the generic features of "the life" of an infrastructure asset. At date t=0, the first ideas about a problem requiring an investment are formulated. Based on a crude description of the situation at hand, the detailed project design is initiated at t=1. At t=2, construction is initiated based on the detail plan produced during the previous period. When the project is opened for traffic at date t=3, maintenance commences. The road surface has to be renewed every 10 to 20 years and may require a major rehabilitation before the end of the project's life, T.

4.1 Design-Bid-Build

It is difficult to get an overview over how different countries organise their procurement contests and what contract format is subsequently used. The DBB procedure applied in Sweden will therefore be used in this section to characterise what seems to represent procedures used elsewhere as well.
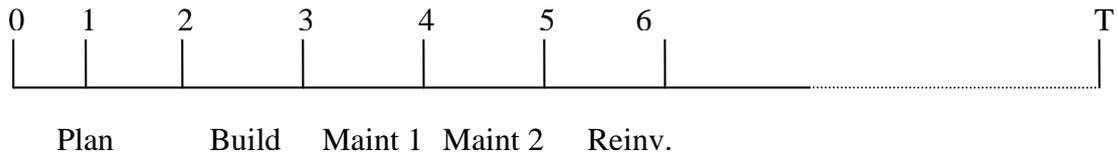

Figure 2: Time line

A first feature of the traditional framework is the unbundled procurement of all separate tasks. The tradeoffs between costs at different points of time are therefore the responsibility of the procuring agency. The tool for implementing these tradeoffs is to use the same manuals as when construction and maintenance were in-house activities. Second, the activities to be undertaken during the $t=2$ detailed planning, the $t=3$ construction and $t=6$ reinvestment phases are described in terms of input activities rather than as a description of the qualities of the resulting road, bridge etc. In contrast, the $t=4$ maintenance phase is increasingly described in terms of the standard to be delivered. Third, the payment model is based on the measurement of all single input activities, which are then multiplied by unit prices.

The combination of input specification and a Unit Price Contract (UPC) for cost reimbursement, used for $t=2$, $t=3$ and $t=6$ contracts, provides the economic logic of the relationship between the procurement principal and the agent doing the job. To see this, consider the outcome of the $t=2$ detailed plan, which quantifies all activities that have to be carried out in order to have a road built. This includes hours of work to undertake meticulously defined tasks, volumes of clay, gravel, rock and

asphalt to be moved from here to there and a host of other (observable and measurable) input activities

$\bar{x}_i$, i=1,…,n. This is made the core of the quote for bids for construction at t=3.

Each interested entrepreneur submits a bid B comprising the unit price, p_i, for each input required to

have the road built. The aggregate bid from the winning bidder is $B = \sum p_i \bar{x}_i$. Disbursements are

made according to actual volumes up to $\bar{x}_i$.

The UPC puts cost risk with respect to the p_i's on the agent while the principal is responsible for any

deviations from $\bar{x}_i$. If the estimation of workload is risky, for instance due to problems with the

geotechnical preconditions for a project, it may be efficient to relieve the more risk-averse agent from

carrying this risk. But even in the presence of completely external sources of risk, there is reason to

have the agent accept at least some risk. If not, the builder will have no incentives to hedge against the

possibility of negative cost realisations or to reduce the consequences of a negative realisation, should

it occur (cf. the previous reference to Milgrom & Roberts 1992).

The UPC moreover provides no incentives to make productivity enhancing changes in the way a

project is implemented, once the contract has been awarded. This is potentially important since the $\bar{x}_i$

vector is based on ex ante estimates without regard to the precise skills and equipment of each

contractor. In addition, the situation at the work site may differ from the ex ante estimate. Still, a

contract which specifies a maximum volume of $\bar{x}_i$ generating revenue $p_i \bar{x}_i$ discourages the agent

from using some alternative approach that would only require $\tilde{x}_i < \bar{x}_i$ even if the implementation

process makes it obvious that it would save on costs. On the contrary, the contractor has reason to

claim that $\bar{x}_i$ underestimates the actual quantity. While the UPC format preserves the motives for

saving on p_i relative to the bid that is submitted, for instance by purchasing more cost efficient

equipment, it provides no incentives for productivity enhancement once the builder has been

identified. Since volume estimates often have to be adjusted during the implementation process[4], $\bar{x_i}$ may become a volume floor rather than a ceiling.

Unbalanced bidding is another potential problem of a UPC contract. A bidder who believes that the assessment of $\bar{x_i}$ is incorrect can increase p_i on quantities that are believed to be underestimated, simultaneously reducing bids on items that have been overestimated. B is then left unaffected, but the expected earnings increase. Unbalanced bidding reduces the potential of a bidding contest to identify the most cost efficient agent since there is no automatic link between making better estimates of work volumes and being most efficient. Ewerhart & Fieseler (2003) argue that UPC may still have a potential for efficiency in that it sharpens competition by also giving less efficient bidders scope for remaining in the market. Bajari et al (2007) report that unbalanced bidding is not a major issue in the contracts they have analysed.

Apart from volume adjustments, the very nature of projects may have to be adjusted after the winning bidder has been named and the construction process is initiated.[5] The costs of the necessary change orders have to be negotiated on a bilateral basis between the principal and the agent, which may push up costs considerably. Bajari & Tadelis (2001) argue that these cost increases may be higher under fixed price and UPC cost reimbursement than if costs are reimbursed on going concern, since the latter requires close and regular communication between the parties, which facilitates monitoring of the way in which change orders are dealt with.

To sum up, DBB is an instrument to ascertain that the procurer is really buying the product as defined by the manuals already developed when the principal was using in-house recourses to implement activities. The implementation programme – the $\bar{x_i}'s$ – detailed in the quote for bids is the principal's belief about what is the optimal implementation, meant to guarantee the delivery of a high quality road

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[4] The Swedish Road Administration makes a standard 10 percent reservation in the budget to account for that $\bar{x_i}$ has been underestimated.

(i.e. $q*$) so that excessive maintenance due to poor design or implementation is avoided. Nothing is left to chance or to the discretion of the entrepreneur, who first and foremost is regarded as an engine for construction, i.e. for completing a detailed programme to the last nuts and bolts. This differs from using in-house resources primarily in that there is competition for each contract. Competitive procurement using DBB with Unit Price Contracts may deliver substantial cost savings compared to in-house production,[6] but it does not make use of the innovative potential of commercial firms. Taken together, these downsides with DBB may provide one explanation for the lagging performance of the industry.

4.2 Design-Build

The quote for bids for a Design-Build (DB) contract is sent out at t=1 rather than at t=2. The quote, moreover, describes a road with certain overall qualities that should be made available. Rather than detailing the project inputs, the contract specifies that a road with a certain width, alignment and other descriptive characteristics is supposed to be built. The specification of output, though, has to take into account the fact that the road-to-be has to have a standard that optimises the tradeoffs between current and future costs as captured by equation (3). DB differs from DBB in that the contractor does the detailed design and chooses construction methods, i.e. implementation methods are established by the contractor who will do the work. All decisions on the allocation of contracts at t>2 are taken in the same way as under DBB.

Under DB, UPC is substituted by a fixed price contract, providing stronger incentives for cost savings. The increased risk that the contractor has to accept is balanced by the fact that restrictions on the way in which a contract is to be implemented are relaxed. This provides scope for the entrepreneur to deal with unanticipated conditions at the site in the best way possible, given the output specification.

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[5] One domestic example is a large project where interchange, which had not been planned, had to be constructed. After negotiations between the parties this added almost 10 percent to construction costs.
[6] Arnek (2001) estimates the costs savings when Sweden's road maintenance was outsourced, from 1993 and onwards, to be in the 15-30 percent range.

A downside of DB contracts is that all bidders must prepare their own detailed project planning before submitting a bid, inevitably generating a degree of cost duplication.[7] These costs may be reduced, at least to some extent, if the principal undertakes parts of the costly background work for volume estimates, for instance by making geotechnical surveys available to all bidders. It is still necessary for each bidder to identify the idiosyncrasies of a project, based on site examinations made by both own staff and external experts, in order to make cost estimates and to pinpoint the types of risk that have to be dealt with.

To avoid placing too much risk on the agent, exceptionally risky aspects of an assignment can be singled out and dealt with separately from the fixed price contract. In 2005, the Swedish Road Administration signed a SEK 555 million contract with a builder for a new 7 km highway. One part of the project was a 1.1 km tunnel. With the quality of the rock being uncertain, the quote specifically asked for separate bids for the tunnel and the rest of the project. It also indicated that the builder could retain 40 percent of any cost savings made and had to accept 30 percent of cost overruns, relative to the bid for the tunnel part of the project. Of the winning bid, SEK 51 million was for the tunnelling.

To summarise, the DB sharpens incentives for cost savings by granting the builder more flexibility during the project's implementation phase. The principal, however, retains the responsibility for the tradeoffs between construction and maintenance necessary for implementing q^*. The agent is therefore still circumscribed when it comes to the choice of many design parameters.

4.3 Performance contract and bundling

A further step to enhance the entrepreneur's control over, and responsibility for, the way in which a project is built is to extend the construction contract to also include maintenance and renewals. Initially assuming that the contract extends into eternity, a performance contract[8] bundles a DB-type

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[7] To the extent that a firm considers submitting an unbalanced bid, at least some exercise of this nature is required under a DBB scheme.

[8] In a World Bank paper, Stankevich et al (2005) refer to performance contracts as first and foremost renewal contracts that also include several years of maintenance. In Sweden, performance contracts are labelled "functional contracts".

investment project with subsequent maintenance and renewal activities, replacing the sequence of procurement contracts in figure 3 with one single document.

In the same way as for DB, performance contracts are signed with a fixed price reimbursement of construction costs, possibly in combination with incentivising clauses. Payments for maintenance costs are routinely indexed in order to make the principal carry the risk for unexpected changes of absolute and/or relative price levels.

A performance contract is a Public-Private Partnership minus financing; the financing part is discussed in the next section. The conventional wisdom in the literature on the welfare properties of PPPs is that the bundling of construction and operations induces the contractor to internalize, at the operations stage, cost reductions that are brought about by the original investment. More (or less) may be spent on the investment in order to save on (accept higher) future maintenance costs, provided that life-cycle costs come down. Even if the industry's standard manuals and methods can still be used, this is at the discretion of the entrepreneur.

Equation (3) and figure 1 show that bundling may encourage choices that optimise construction and maintenance costs at the expense of service quality. Rather than detailing the methods to be used (the inputs in DBB procurement) or the qualities of the road at opening (the output specified by a DB procurement), the quote for bids must establish the functional targets – the performance standards – that should be delivered during the service life of the contract. The agent will subsequently be reimbursed for the annual maintenance costs according to whether these targets have been met or not.

A core proposal of this paper is that the ex ante design of appropriate parameter values is straightforward. This is so since the value of availability, time savings, reduced accident risks etc. has been made available to undertake the Cost Benefit Analysis (CBA) preceding the decision to build the

road. CBA for infrastructure investment has a long history[9] and research on the appropriate parameter values is intense. As always, uncertainties remain but most probably not more so than in any material required for decision making.

The quote for bids must therefore condition payments on the principal's knowledge about c_u^q and c_3^q. Since C^q is the contractor's private information, incentives must be given to implement q^* rather than $\hat{q}$. A performance contract will therefore have to quantify at least the following parameters:

➢ Availability: Payments from principal to agent for a new piece of infrastructure must be conditioned on lanes or sections becoming available for use, and on being available for the duration of the contract. Technically, this may be done by making the first disbursement contingent on the project being open for traffic, possibly in combination with a penalty/bonus to punish/remunerate late/early opening. The strength of the incentives can be calculated based on users' travel time savings. In the same way, availability clauses can provide incentives for undertaking (planned) maintenance activities during off-peak periods of the day or of the year.

➢ Road surface quality: The quality of travelling deteriorates when a road gets increasingly uneven. Rough rides have consequences for the time of a journey, for vehicle operating costs, for riding comfort and possibly also for safety. CBA parameter values are available to estimate these consequences for users, while the contractor's maintenance costs $c(q)$ is private information. Based on ex ante estimates, it is still feasible to estimate $c(q)$ and consequently pinpoint a proxy for q^*, say $\tilde{q}$. Deviations from $\tilde{q}$ can be penalised/rewarded according to an incentivising scheme.

➢ Safety: Other contractor activities, apart from road surface quality, may affect road safety. Examples include snow clearance, maintenance of street lights, road markings and side-rails as well as clearing of side areas in order to reduce the risk of wildlife accidents. These aspects may be complex to steer by using economic incentives but can be dealt with by minimum

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[9] The World Bank manual is available at worldbank.org/transport/roads/tools.htm and a similar document from

standard clauses in the contract. In addition, the actual number of accidents can be benchmarked against risks on other similar roads in order to punish poor and remunerate good performance.

➢ Environmental concerns: To the extent that the principal has information on how environmental externalities may be mitigated by changes in construction or maintenance activities, these concerns should be included in the contract; cf. the previous examples in which the choice of material of a road's top layer may have consequences for the extent of noise from traffic and particles worn off by studded tires. Again, it could be done either by way of direct instructions or with bonus/penalty constructions linked to the annual remuneration.

Ex ante information about user benefits and the information required to monitor performance are already readily available from today's institutions. For example, information on when a project is to be opened for traffic and lane closures due to maintenance or accidents is straightforward to collect. Road surface smoothness (rut depth and longitudinal waves) are routinely measured. Essential aspects of quality can therefore be controlled in a performance contract to reduce the risk of substandard quality in long contracts to build and maintain roads.

To conclude, since quality is contractible – i.e. can be specified ex ante and monitored ex post – the risk that savings on investment and maintenance costs are made at the expense of users is small. Bundling therefore dominates the separate procurement of investment and maintenance in infrastructure projects.

The discussion has so far been based on the assumption of a perpetual maintenance contract, which induces the contractor to internalise any and all implications of the choice of construction quality for future maintenance and user costs. There are obvious problems with never-ending contracts. One is that the initial tendering contest may generate high bids to insulate the winning contractor against an

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the European Commission at ec.europa.eu/transport/sustainable/2008_external_costs_en.htm

uncertain future. Moreover, any and all future improvements in cost effectiveness in maintenance will benefit the contractor. It is therefore reasonable to consider contracts of shorter duration.

The prime trade-off in the choice of contract duration lies in the necessity to induce the contractor to internalise the consequences of the choice of the construction standard. In particular, it is vital to avoid a situation in which the contractor optimises construction so that performance criteria are satisfied during the contract period, but the quality of the asset plummets shortly after it is handed over to the principal.

But tradeoffs in engineering design with respect to life length are highly imprecise. It is therefore difficult to design the construction of an asset at t=1 to pinpoint precisely when the rate of deterioration accelerates. This may mean that the contract could cover a period of one or two expected renewals in order to avoid any excessive strategic policy of shirking with regard to long-term quality in order to save on investment costs.[10] It is also straightforward to reintroduce some specific technical restrictions on construction in the contract, and to insist on an inspection both before and at hand-over with quality requirements that have to be met. Both techniques may constrain the contractor's control over design and the possibility of implementing innovative construction solutions, but will reduce the threat of future needs for extensive rehabilitation of malfunctioning assets.

4.4 Public Private Partnership

Public Private Partnerships (PPP) are often thought of as a mechanism for bundling investment and maintenance into one single contract. Here, PPP is rather defined as a combination of bundling and external funding: a PPP is a performance contract where the contractor uses a combination of equity and external loans to have the project built, and where construction costs are repaid during the lifetime of the contract.

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[10] A Swedish performance contract was signed for 15 years maintenance after traffic opening. The argument seems to have been that any construction failures would have materialised within that time span.

There are different ways for the contractor to recoup the initial costs. The focus here is on situations where costs are recovered by the government making availability payments to the contractor. It can be demonstrated that this logic also carries over to tolling models. Based on the original bid, the contractor is thus compensated for annual maintenance costs plus a down payment, for instance an annuity of the initial investment cost. Compensation is affected by performance by way of carrot-and-stick clauses according to the design outlined in the previous section.

Figure 3 pinpoints the difference between a PPP and a performance contract for a particular numerical example. [11] The performance contract remunerates the entrepreneur for investment costs during the construction period and for maintenance costs during the rest of the contract period; this is the graph with diamonds. The upper graph with squares, starting in year 4, illustrates disbursements under the PPP alternative, assuming an annuity to pay back the investment costs plus the annual maintenance cost and the spending on recurrent reinvestment.

An obvious drawback of having the contractor raise project financing is that commercial firms are charged a higher interest rate than a public sector representative for borrowing the same amount of money. In view of the fact that the private borrower has a contract with the public sector, which guarantees an income stream to service the debt, the difference in interest rate is not necessarily large.

There are two arguments to balance this cost increase. First, any potential lender will make a detailed review of the project in order to assess the downside risk of the loan. This includes due diligence analyses of any technical aspects of the project proposal that may affect its financial viability. The review could, for instance, scrutinize the intertemporal trade-offs between investment and maintenance costs in the investment proposal. This scrutiny not only benefits the lender but also increases the chances for a project as a whole to be beneficial. External reviewing on a commercial basis is typically

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[11] The figure is constructed assuming that the project lasts for a period of 40 years, whereafter it has no scrap value. It costs 330 to build the project, 110 for each of three years of construction. The annual maintenance cost is 1 percent of the total investment, increasing by 1.5 percent per year. Every 12th year a reinvestment, which

much more scrupulous than when project finance is raised as part of the state budget. The interest rate differential is therefore at least partially a payment for risk monitoring and reduction.
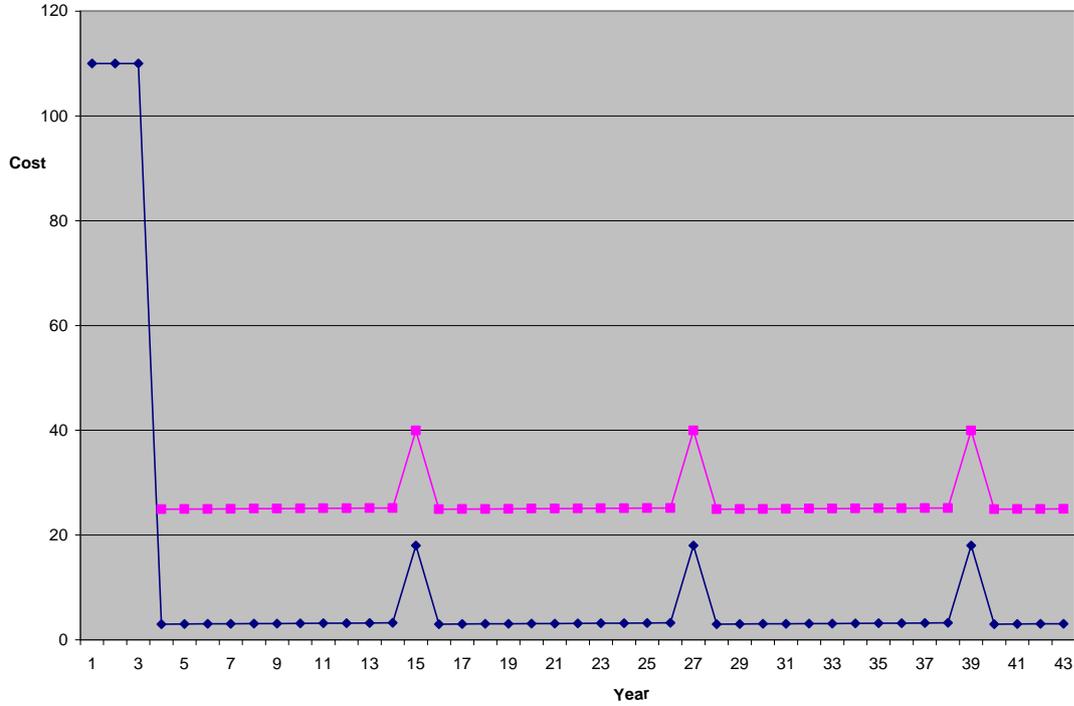

Figure 3: Life cycle costs (lower graph) and annual maintenance cost plus investment cost annuity (upper graph) for an infrastructure investment.

A second argument for private financing is that it may operate as a lever to enhance the agent's commitment to the contract in a world of opportunism and incomplete contracts. To see this, the financial streams under a performance and a PPP contract will have to be compared. In both situations, it is assumed that the agent is corporatised in the shape of a special purpose vehicle (SPV) to insulate the ultimate owners against extreme risk exposure.

Assume now that an unanticipated quality problem appears in year $t<T$, making it necessary to increase maintenance costs from c to $\hat{c}$. Under both contracts it is assumed that the SPV has built the

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costs 6 percent of the investment cost, is undertaken. After this new pavement has been laid, maintenance costs drop to the original level of 1 percent of the investment cost again. The discount rate is 4 percent.

project according to its own specification in order to optimise costs over the life of the contract. With a fixed price contract the entrepreneur is accountable for cost increases of this nature.

Under a performance contract, the SPV is reimbursed for initial investment costs but will only receive c to pay for maintenance costs $\hat{c} > c$. If the difference between $\hat{c}$ and c is large, or with little or no own capital left, the SPV risks going bankrupt. The principal's choice is between increasing payments to $\hat{c}$ or taking over the facility and re-letting it, but probably still having to pay a higher maintenance cost than stipulated by the original contract.

Under a PPP contract, the SPV annually receives not only c but also D+p, where D is the payment to service debt to lenders and p the investor's rate of return on the capital provided for the construction. Again, costs have increased to $\hat{c} > c$ at date t and the SPV will seek to renegotiate the contract. The threat of bankruptcy would now be less credible. As long as $(\hat{c} - c) < \pi$ the principal could ask the entrepreneur to abstain from (parts of) p. If $(\hat{c} - c) > \pi$ so that the annuity is no longer sufficient to service the debt, the claim for renegotiation is obviously more valid. The conclusion is therefore that there is scope for bargaining and that the principal will not necessarily have to pay the full cost increase. [12]

The significance of this shift of bargaining power may be further emphasised by backtracking to the situation when the project was first tendered. Each bidder will then make an own estimate of project costs and the lowest aggregate bid B wins the contest. Assume for simplicity that each bidder has a choice between two strategies. Strategy I combines a high (h) investment cost with low (l) future maintenance costs while strategy II has the opposite combination; ε is a random term.

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[12] The Arlanda railway link is a Swedish PPP contract signed in 1993 with services opening in late 1999. Shortly after, the September 11 attack had severe consequences for international air traffic and for patronage at the airport and on the train, and put the operator of the airport commuter service under severe financial strain. The financing solution established in the 1993 contract, however, meant that the SPV could not expect the government to make up for the losses. In case of bankruptcy, the owners would have lost their risk capital while

$$B^I = k^h + c^l + \varepsilon$$

$$B^{II} = k^l + c^h + \varepsilon$$

Assume furthermore that the winning bidder – in spite of actual costs following strategy I or II – submits a (non-realisable) bid $\widetilde{B} = k^l + c^l + \varepsilon$. $\widetilde{B}$ is on average lower that any bid submitted by competitors following strategy I or II. Some years into the contract maintenance costs will start to grow, and the bidder will seek to renegotiate the contract. As demonstrated above, the chances for successful renegotiation are then higher under a performance contract than under a PPP contract.

The conclusion is therefore that, apart from providing additional outside monitoring, a PPP contract also contributes to disciplining the agent into submitting bids that may be expected to be viable for the whole life cycle of the contract. This is particularly important in view of the long contract periods and the impossibility of taking into account, or indeed envisaging, all the feasible contingencies at the date of contracting. A contractor may claim that cost increases are due to external events not taken into account in the original contract, while they in reality may be due to poor effort or incorrect investment decisions.

Still, the long contracting periods also mean that much may happen that cannot be anticipated at contract closure, and renegotiations should be seen as something natural.[13] Many of the frequent adjustments and complementary investments that have to be made on fairly new roads or railways could indeed be conceived of in this way. The advantage of using private investment resources to pay for PPP investments lies in the fact that it increases the chance that the parties will deal with any future renegotiation in a balanced way. The risk that the taxpayer will have to foot the bill, due not only to random events that are bound to occur, irrespective of whether a project is implemented within the

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the banks would have retained their claims on the company. Losses were therefore covered by owners and after a couple of years, results were again in the black. Se further Nilsson et al. (2008).

[13] "Commitment does not mean that the parties will abide by their contract in the future but only that the contract will be implemented if at least one of the wishes so. The parties are always free to agree to modify the contract to their mutual advantage. Full commitment is an idealized case." Laffont & Tirole 1993, p 437)

public sector or by way of some procurement strategy, but also to poor project construction caused by fallacies in contract design, is therefore reduced.

5. Conclusions

Governments around the world seem to be pushing for PPP contracts, but partly for the wrong reasons. One motive is the wish to circumvent fiscal restrictions on deficit spending and the size of public sector debt. In some countries restrictions have the shape of budget balance or surplus rules; in (much of) the EU it is Maastricht criteria for fiscal stability that are bypassed. Mince and Smart (2006) demonstrate that this is but a motive for fooling oneself.

Another reason for the growth of PPP contracts is the belief that it is a tool for attracting new funds. To the extent that PPPs are introduced as a mechanism for introducing a capital-spending budget, there may indeed be some extra scope provided for additional (investment) spending during a short period. Before long, down payments on the accumulating debt will start to grow and, in steady state, the only difference between financing by means of the current or a capital budget will be the extra interest costs incurred under the latter strategy (cf. OECD 2008, in particular ch. 8 for a simple numerical example plus a description of countries where this has happened).

A third motive for the introduction of PPPs, which is also based on the idea of attracting extra financing, is that projects can be paid for by way of user charges. Although there certainly are situations where, for instance, a road toll may be efficient, there is nothing that makes this an intrinsic feature of PPP contracting; tolls can be implemented without a PPP contract backing it.

The focus of this paper has rather been on the potential efficiency qualities of PPP projects. National accounting data indicate that the construction industry's productivity performance is well below the average for industry at large in several countries. There are probably a number of reasons for this feeble performance, but it is reasonable to include the micro-foundations of standard contracting procedures in the industry, in particular the rigidities superimposed by Unit Price Contracts, on this

list. This paper has argued that PPP projects offer a way to loosen the tight ties of the received way to contract in the sector. Even if PPPs may not be appropriate to use for all types of projects, they facilitate the testing of novel construction approaches that subsequently may spread to other parts of the industry.

A second result of the analysis is that instruments are available to control for user benefits and costs in the performance clauses of a contract signed between public sector principal and private sector agent. The quality tradeoffs in the bundling dimension of PPP's, discussed in both the asymmetric and incomplete information literature, can thus be controlled for in infrastructure contracts.

A third conclusion is that the risk of poor commitment is at least partly dealt with by way of the contractor's obligation to finance the project with loans and risk capital. It has been demonstrated that this may be seen as a mechanism for reducing the risk that the winning bidder may base the victory on the presumption that future negotiations can make up for cost increases in maintenance due to a sloppy construction design.

In view of the extensive interest in PPPs, it is surprising that relatively few ex post assessments have been made. One obvious reason is that most long-lived PPPs are still under operation, making it impossible to summarise their life-cycle performance. Three micro-based reviews of European experiences have, however, been made of the situation after the construction part of the contract has been completed; (CEPA 2005, NERA 2003 and Sandberg et al 2007).[14] These studies seem to have at least three features in common; that PPP projects are opened before or on time while standard contracts often run late; they face fewer cost overruns than their peers; but there are no indications of cost savings for the principal.

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[14] In addition, experiences from South America are discussed by, for instance, Guash (2004) and Guash et al (2008).

All three features could be rationalised within the framework of this paper. No payment for services rendered by a contractor is to be made before the project is opened to traffic, providing strong motives to be on time. PPP contracts make extensive use of fixed price reward schemes, which reduce the possibility of demanding compensation for cost overruns. Besides, there may be several reasons for the fact that no cost savings are reported. One is that bidders could have padded their bids in order to bolster the risk of cost increases in long-term contracts; another that construction has been made more expensive in order to save on future maintenance and thus reduce life cycle costs. In addition, there are indications that representatives of the principal have problems with letting the conventional wisdom of their manuals go. Moreover, contracts that are said to be signed on performance criteria may therefore include restrictions on the way in which the projects are to be built. This would eliminate one potential source of cost savings.

Several claims made in this paper, in particular regarding what is referred to as traditional procurement, are based on a semi-structured discussion rather than on rigorous empirical scrutiny of data. Much remains to be done to improve the performance of the public sector's purchase of goods and services. Even so, this paper has argued that Public Private Partnerships may fit into the toolbox to enhance efficiency.

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