Assigning Tasks in Public Infrastructure Projects: Specialized Private Agents or Public Private Partnerships?

Karl Morasch*, Rita Orsolya Tóth†

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Abstract

What criteria should be considered when deciding about allocating the different tasks in an infrastructure project to private and public agents? Traditionally, building the physical asset is assigned to private partners, whereas financing and operation are carried out by the public sector. But even if building, operating and possibly financing is delegated to the private sector, the question remains, whether all these tasks should be accomplished by a single private agent in the form of a Public Private Partnership (PPP) or, alternatively, each task should be assigned to a different firm. While proponents of PPPs highlight possible efficiency gains, critics of private solutions fear quality problems and doubt that private financing of public projects would be sensible.

Applying an incomplete contracts approach we consider informational asymmetries as well as investment incentives. We show how the specifics of projects and potential agents as well as the character of interaction between the three main tasks of building, operating and financing determines the preferable institutional design. Whether building, operating and financing should be bundled within a PPP is shown to depend crucially on how uncontractible investments in the building stage influence operating costs and service quality.

To demonstrate the usefulness of our approach, we apply the theoretically derived criteria to a specific PPP–project: The federal motorway A8 between Augsburg and Munich. In this PPP the private partner is not only responsible for the extension of the motorway from four to six lanes but also for future operating and for the main part of financing. The private consortium obtains the toll from freight vehicles, but as there is no toll for passenger cars there is also an additional start–up financing from the federal government budget. This setting is particularly interesting with respect to the allocation of the financing task and the way it deals with the problem of limiting the risk of operation for the private partner.

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*Address: Prof. Dr. Karl Morasch, Fakultät für Wirtschafts– und Organisationswissenschaften, Bundeswehr University Munich, D–85577 Neubiberg, Germany, phone: +49–89–6004–4201, fax: +49–89–6004-2374, e-mail: karl.morasch@unibw.de

†Address: Dipl.–Vw. Rita Orsolya Tóth, Fakultät für Wirtschafts– und Organisationswissenschaften, Bundeswehr University Munich, D–85577 Neubiberg, Germany, phone: +49–89–6004–4284, fax: +49–89–6004-2374, e-mail: rita.toth@unibw.de

1 Introduction

All around the world governments are looking for new ways of providing public services and infrastructure. Tasks that have usually been performed by the public sector are now delegated to private agents. One specific form of such kind of delegation is a Public Private Partnership (PPP). While the concept itself dates back at least to France in the 17th century [1], it was only quite recently that the economic literature started to deal with PPPs. Public interest seems to be triggered by so called "Private Finance Initiative" that has been launched in the United Kingdom in 1992. Initially PFIs were concentrated in the transportation sector, but recently they are used in a wide range of areas, including hospitals, schools and roads.

From an economic point of view, the bundling of different tasks (building, operating and financing) is one of the core features that distinguishes PPPs form other forms of public procurement. Following Iossa and Martimort (2008) we compare unbundling and different forms of bundling in an incomplete contract framework. In a moral hazard context with a risk averse contractor we discuss how different institutional forms affect investment incentives and risk shifting. We consider two kinds of PPPs: In the base case taken from Iossa and Martimort (2008) the PPP is restricted to building and operating. In this setting a PPP is shown to be preferable to unbundling if a quality–enhancing investment in the building stage also reduces the operating cost (positive externality). Having in mind our application — the PPP that is in charge to build, operate and (partially) finance the motorway A8 between Augsburg and Munich — we extend the analysis by considering explicitly that the quality–improving investment may also boost demand for the service. If private financing is coupled with repayment via user charges, such a design of the PPP may provide investment incentives in cases with a negative cost externality. However, as demand risk is shifted from the (risk neutral) government to the contractor, it is not obvious whether this kind of PPP actually yields higher welfare. We therefore analyze in detail how the impact of the investment

[1] See e. g. Grimsey and Lewis (2005) and de Bettignies and Ross (2004).

on cost and demand as well as the risk parameters determine the optimal institutional design.

Our paper is closely related to some other contributions to the economic theory of PPPs. The first to mention is a seminal article by Hart (2003). Using an incomplete contract approach, he analysis the conditions under which bundling of building and operating is preferable. Ignoring the choice between public and private ownership, he concentrates on the bundling decision in a setting with two kinds of investment in the building stage. Both investments decrease operating cost, but only the first one is productive in the sense of improving the quality of the service while the second one is unproductive, i. e. reduces service quality. It is shown that bundling is preferable if the quality of the service can be well specified (and therefore contracted upon) while the quality in the building stage is less easily observable. Bennett and Iossa (2006) also analyze the choice between traditional service provision (unbundling) and PPP (bundling). However, they differ from Hart (2003) by considering different ownership structures and by assuming that there is only one kind of investment on the building stage. This investment can have either a positive or a negative impact on the operational costs depending on an externality parameter. It is shown that the bundling of tasks within a PPP is optimal in the case of a positive externality, whereas with a negative externality one should choose the traditional way of service provision. The same result is obtained in Martimort and Puoyet (2008) in a agency setting with complete contracts. Beyond that they also consider different ownership structures and address some aspects of the political economy of PPPs.

The remainder of the paper is organized as follows: In section 2 we abstract from the shifting of demand risk and restrict attention to the basic setting described in Iossa and Martimort (2008): Bundling or unbundling of building and operating. In section 3 we extend the analysis by considering the possibility to shift some of the demand risk to the PPP. We show under what circumstances a PPP is preferable. In section 4 we apply the criteria to a specific PPP–project, the motorway A8 between Augsburg and Munich, to demonstrate the usefulness of the theory and section 5 concludes.

2 Bundling of construction and operation

The paper from Iossa and Martimort (2008) attempts to provide some theoretical framework on the incentive issues regarding PPPs. On the basis of a unified model the authors identify the circumstances under which a PPP seems to be preferable compared to traditional public service provision. For this purpose they define three key characteristics of PPPs.

The first main feature is the bundling of different tasks. In general it involves the bundling of the design, building, operation and financing of a project. These tasks are then contracted out to a private agent or to a consortium of private firms. A consortium usually consists of a construction company and a management company, that operates the facility after it is built. The consortium is responsible for all aspects of the service. The three most well–known models for bundling of tasks are the DBFO (Design–Built–Operate–Finance), the BOT (Build–Operate–Transfer) and the BOO (Build–Own–Operate) types. They all account for bundling of the building and operation stages, however with differences in degrees.

The second key characteristic relates to the higher risk transfer to the private sector in the case of PPPs. Compared to the traditional public service provision a PPP contract involves transfer of risk and responsibility to the private partner. In general, a system of output specification is used. That means, the government specifies the basic services and standards it wants, but leaves the consortium with control rights over how to deliver the required services. So the private contractor usually has to bear a substantial amount of the design, construction and operational risk.

The last key property considered by Iossa and Martimort (2008) is that a PPP contract is a long–term contract lasting in general 25 to 30 years. The payments to the private contractor during the contract period are made by the government (in the case of PFIs) or by the general public as users of the facility (in the case of more standard concession contracts). This feature of PPPs will not be discussed further in the model, but will be addressed later on in the example of use.

In the following simple model of procurement both the aspects of moral hazard and the property rights literature are present. The moral hazard aspect plays an important role regarding two issues. First, in the problem of agency costs born by the governments when delegating different tasks of service provision to the private sector and second, in the problem of risk-sharing between the public and the private sector. First, using the basic model the conditions will be studied under which ones bundling and unbundling of the different tasks of a project is favorable. Thereafter we will present a model that aims at clarifying the connection between investments of the private agent in different stages of a project and the demand risk transferred to the private sector.

2.1 The basic model

In the basic model the government (G) contracts two private firms (F1 and F2) or a consortium (F) to provide a public service for the society within an incomplete contract. The provision of the public service requires that an infrastructure of good quality has been first designed and built. The issue of delegation of tasks must be modeled as a multi-task problem. The main characteristic of a PPP can be viewed then as the bundling of different stages of a project. Typically the design, building, operation and financing of the project are contracted out to a consortium of private firms, a construction and a facility management company. The private agent responsible for the construction of the infrastructure (F1) can exert a quality–enhancing effort, or in other words he can invest in the quality improvement of the infrastructure, which increases the quality of the service and in turn the social benefits. The corresponding function of social benefits is assumed to be

$$B = b_0 + ba, \tag{1}$$

where b_0 is some basic level of benefits, that occurs also without exerting any effort and b is the marginal benefit from the agent's effort a ($b > 0$). Furthermore it is assumed, that the social benefit is not verifiable. The service provision cost of the private agent that operates the infrastructure can be written as follows

$$C = \theta_0 - e - \delta a + \epsilon, \tag{2}$$

where θ_0 represents the innate cost of the service and e is the operating effort in cost–reducing activities exerted by F2 during the operation phase. ϵ stands for any operational risk, that the firm may occur while managing the asset. It is a random variable normally distributed with zero mean and variance σ_ϵ^2. The variable a is already known as the quality–improving effort, but δ still requires some clarification. This latter parameter represents the external effect of effort a on the costs of operation. The case $\delta > 0$ corresponds to a positive externality, which means that an improvement in the quality of the infrastructure also reduces the operational costs. A negative externality on the other hand exists when $\delta < 0$. In this case improving the quality leads to an increase in the operational costs. Both quality–enhancing and operating efforts cause monetary costs for the agent. To keep things simple, these costs are described by two quadratic disutility functions, $\varphi(a) = \frac{a^2}{2}$ and $\psi(e) = \frac{e^2}{2}$.[2] The services are delegated to the private agents in a moral hazard environment so that a and e are both non–verifiable. As already mentioned above, social benefits are also hardly contractible. Only the operating costs C can be observed and used ex ante when the government and the agent sign the contract.[3] The government is risk–neutral whereas the private agent is considered to be risk–averse with a constant degree of risk–aversion $r > 0$. The government maximizes an expected social welfare function, defined as the social benefit of the service net of its costs and of the payment to the private agent. The firm on the other hand maximizes his expected utility.

The timing of the game regarding the organizational structure and contracting is as follows: First the government makes a choice between bundling or unbundling and then he contracts with the operator. After this, the builder chooses a non–verifiable effort a and following, the operator chooses his cost–reducing operating effort e respec-

[2]There are no (dis–)economies of scope between efforts.

[3]Since the principal and the agent face the same cost uncertainty, both of them ignore this aspect.

tively. In the next phase operating costs C and then the social value B are realized.

In the following we describe the benchmark case, which can be helpful in comparing different situations later on. The first–best levels of efforts (a^{FB} and e^{FB}) can only occur, when these are both observable and can be contracted upon. In the benchmark situation the risk–neutral government can fully insure the risk–averse agent through a cost–plus contract. According to this contract contract after having completed the task assigned to him, the contractor receives a compensation equal to his expenses plus a profit. Given, that the government can run a competitive auction to attract potential service providers, it is assumed that it has all bargaining power ex ante. He can choose a fee for the actual service provider so, that it equals exactly his outside option, which is normalized to zero. That means, the private firm is just indifferent between providing the service or not. Additionally, the contract is constructed in a way, that it forces the private agent to choose the first–best effort levels, that maximize social benefits:

$$\left(a^{FB}, e^{FB}\right) = \arg\max_{(a,e)} b_0 - \theta_0 + (b+\delta)a + e - \frac{a^2}{2} - \frac{e^2}{2} = (b+\delta, 1). \tag{3}$$

The first–best quality–enhancing effort a^{FB} trades–off the marginal social value of this effort, including its external effect on the operating costs (δ) and its impact on the social value of the service (b), with its marginal cost (a). The operating effort e^{FB} on the other hand trades–off the marginal benefit of reducing the operating costs (1) with its marginal monetary disutility (e).

In the next subsection the above described basic model will be applied to analyze the circumstances under which bundling of the different tasks of a project is preferred to the case of unbundling, where two specialized agents complete the tasks of building and operating separately.

2.2 Unbundling or bundling? — Pure agency considerations

Unbundling Under traditional provision G contracts the builder of the infrastructure (F1) and the operator (F2) in separate contracts. F1 receives in this case a fixed fee [4] and bears no risk. The fixed payment means that F1 will not be rewarded for effort a, which leads to the result that the builder does not exert any effort at all:

$$a_u = 0. \tag{4}$$

F2 on the other hand receives a cost–reimbursement rule net of its cost. Given the CARA–utility function of the private agent only linear contracts are considered in this analysis. The linear rule takes the form $t(C) = \alpha - \beta C$, where the parameter β represents the power of incentive scheme. If $\beta = 0$, then the cost–plus contract does not provide any incentives for cost reduction, whereas $\beta = 1$ holds for a fixed–price. The operator also has to bear risk and gets a risk premium $\frac{r\sigma_\epsilon^2\beta^2}{2}$. F2 maximizes the certainty equivalent of his expected utility given the builder's effort. His incentive constraint is then

$$(e) = \arg\max_{\tilde{e}} \alpha - \beta(\theta_0 - \tilde{e}) - \frac{\tilde{e^2}}{2} - \frac{r\sigma_\epsilon^2\beta^2}{2} = \beta. \tag{5}$$

The interpretation of the maximization problem is straightforward: An increase in β leads to an increase in the operating cost reducing effort e, but as more operational risk is transferred to the private firm (F2) at the same time, the risk premium increases too. As the assumption holds, that G has all the bargaining power ex ante and so he can just leave the operator indifferent between providing the service or not, the fee α is just set to cover the risk premium, that must be paid to the operator for bearing some of the operational risk.

Finally, the government maximizes social welfare taking into account the incentive constraints of the builder and operator and the total benefit and cost of effort, including

[4] This assumption is justified when G has a limited ability to commit to future rewards for the builder and cannot delay payment for the delivery of the infrastructure.

the risk premium:

$$\max b_0 - \theta_0 + e - \frac{(1 + r\sigma_\epsilon^2)}{2} e^2. \tag{6}$$

As result of the optimization problem we get the second–best level of the operating effort under unbundling:

$$e_u^{SB} = \frac{1}{1 + r\sigma_\epsilon^2} < 1 = e^{FB}. \tag{7}$$

By inserting e^{SB} in G's function the social welfare level is as follows:

$$W_u^{SB} = b_0 - \theta_0 + \frac{1}{2(1 + r\sigma_\epsilon^2)}. \tag{8}$$

Compared to the first–best case both quality–enhancing and operating efforts are lower in the second–best situation. The builder does not exert any quality–enhancing effort a, as the fixed payment he receives does not give him any incentives to do so. The operator does exert some effort e, but since he has to bear more risk, and this is socially costly, the government cannot give him enough incentives to choose the benchmark effort level.[5]

Bundling Under bundling the government signs one single contract with a consortium of private firms. With this organizational form both the tasks of building and operation of the infrastructure are completed by the same entity, the consortium (F). In this case the expected payoff of the consortium is maximized when the effort levels are jointly chosen to solve:

$$(e, a) = \arg\max_{\tilde{e},\tilde{a}} \alpha - \beta(\theta_0 - \tilde{e} - \delta\tilde{a}) - \frac{\tilde{a}^2}{2} - \frac{\tilde{e}^2}{2} - \frac{r\sigma_\epsilon^2\beta^2}{2}. \tag{9}$$

[5]This result is standard with the applied linear–CARA model.

Taking into account that the non–negativity constraint $a \geq 0$ holds, the incentive constraints are as follows:

$$e = \beta \quad \text{and} \quad \alpha = \begin{cases} \beta\delta & \text{if} \quad \delta > 0 \\ 0 & \text{if} \quad \delta \leq 0 \end{cases} . \tag{10}$$

For the analysis we have to consider two cases depending on the sign of the externality (δ).

Negative externality In a situation, when $\delta \leq 0$ the consortium does not exert any quality–enhancing effort a, because it receives no direct reward for it, and as an additional negative impact it increases the operating costs. That means, with a negative externality bundling and unbundling yield the same effort levels and in turn the same social welfare. There is no quality–enhancing effort a in the building stage of the project and the level of cost–reducing operational effort is lower than the optimal:

$$a_b^{SB} = a_u^{SB} = 0 \quad \text{and} \quad e_b^{SB} = e_u^{SB} < e^{FB} \tag{11}$$

The social benefits are in turn equivalent in both cases:

$$W_b^{SB} = W_u^{SB}. \tag{12}$$

Positive externality Under bundling with a positive externality ($\delta > 0$) the situation is slightly different. The consortium (F) maximizes its expected payoff by choosing both the quality–enhancing and operational effort levels jointly. Bundling in this case induces F to internalize the impact of the quality–improving effort a on the operational costs to some extent. The increase in the power of the incentive scheme β

or in other words moving to a fixed–price contract now raises a. This is an objective, which cannot be directly achieved by the government, since quality is not contractible. Thus risk transfer is more effective on incentives under these conditions. As the result of the maximization problem of F the following effort levels are obtained:

$$\tilde{e} = \beta \quad \text{and} \quad \tilde{a} = \beta\delta. \tag{13}$$

Turning to the social welfare the government's maximization problem is as follows:

$$\max b_0 - \theta_0 + (b+\delta)a + e - \frac{a^2}{2} - \frac{(1+r\sigma_\epsilon^2)}{2}e^2 \tag{14}$$

subject to $a = \delta e$ according to (13). The first–order conditions yield then

$$e_b^{SB} = \frac{1+\delta(b+\delta)}{1+\delta^2+r\sigma_\epsilon^2} \quad \text{and} \quad a_b^{SB} = \delta e^{SB}. \tag{15}$$

Using these effort levels we obtain the exact expression of the expected welfare and the efforts under bundling with a positive externality. The comparison of these levels of social welfare and efforts a and e with those under unbundling and bundling with negative externality yields the following results:

$$W_b^{SB} > W_u^{SB} \quad \text{and} \quad a_b^{SB} > a_u^{SB} = 0 \quad \text{and} \quad e_b^{SB} > e_u^{SB}. \tag{16}$$

First, with a positive externality bundling strictly dominates unbundling, as the social welfare is higher and the welfare gain increases with the magnitude of the externality δ even further. Second, both quality–enhancing and operational efforts increase compared to the earlier second–best cases. Thus PPP projects with a positive externality are associated with higher powered incentives and more operational risk is transferred to the private agent. It is also important to mention that moving from traditional service provision to PPP changes the cost–reimbursement rule. Bundling and fixed–price contracts are common under PPPs, whereas unbundling and cost–plus contracts usually occur under the traditional way of procurement. Furthermore we have to underline that the outcomes of the analysis are unchanged also if a complete contract environment is assumed. Although in latter case better information over the asset quality is available, thus the agency problem under unbundling is eased, the result that bundling with a positive externality is preferred still holds.[6]

3 Financing and sharing of demand risk

Until now we concentrated on the incentive to bundle building and operation within a PPP due to a positive externality of a quality enhancing effort at the building stage. We assumed that the contractor is only concerned with the effect of the effort in the building stage on the operating cost. However, in many cases the contractor has to take some part of the demand risk and must at least partially finance the project. These two aspects are often interrelated as the contractor is allowed to collect user charges to cover at least partly the costs of the initial investment on the building stage as well as the operating costs. We suppose that taking into account that demand risk is transferred to the private agent bundling is still the best choice in the case of a positive externality and even if a negative externality can be observed, bundling of different stages might be preferable since the quality enhancing effort also increases the demand and this effect might dominate the negative impact on the operating costs.[7]

In order to analyze the situation we extend the model from the last section by assuming that the social benefit of the project is divided in two parts: One part that depends on the demand D of consumers that have to pay the user fee and the other part that incorporates any additional benefit B for the society (for example to consumers that do not have to pay the user fee as in the case of a toll that is only applicable for heavy vehicles). We assume that consumers have inelastic demand for the service up to some

[6] For details see Iossa and Martimort (2008)

[7] In the following model we are analyzing directly the second–best case without considering the first–best situation, since the aspect of demand risk is what we are interested in.

price level p_0:

$$D(p) = \begin{cases} d_0 + a + \eta & \text{if} \quad p \leq p_0 \\ 0 & \text{if} \quad p > p_0 \end{cases} . \tag{17}$$

The random variable η is the demand risk. It is normally distributed, with zero mean and variance σ_η^2. d_0 stands for the basic level of demand and a corresponds to the quality enhancing effort from the basic model. The difference in this case is that the effort a also affects the demand level in the operating phase: the higher the effort level, the better the quality of the infrastructure and the higher the demand for the service. The cost of effort is still $\frac{a^2}{2}$.

A first best contract would fully insure a contractor that is most likely to be more risk averse than a government. But in the reality — especially considering a contract length of 20 to 30 years — demand uncertainty is an important issue. Taking into account the demand risk and that the government is able to extract all profits from the consortium the function of social benefit can be written as follows:

$$B = b_0 + ba + p_0(d_0 + a + \eta). \tag{18}$$

Furthermore, the firm can extract all consumer surplus by means of a fixed–fee (for instance user charges in the case of motorway) and so he gets the expected revenue:

$$E_\eta = pE_\eta(\max d_0 + a + \eta, 0) \approx p(d_0 + a). \tag{19}$$

The approximation holds, when σ_η is small enough compared to the base level of demand b_0. The operating costs of the consortium are unchanged:

$$C = \theta_0 - e - \delta a + \epsilon, \tag{20}$$

where e is still the operating effort of the firm, whose disutility counted in monetary terms is $\frac{e^2}{2}$. θ_0 is the innate cost of operating the facility, δ is the externality exerted by the quality enhancing effort a on the operating cost and ϵ is a random variable capturing any operational risk. It is normally distributed with variance σ_ϵ and zero mean.

Taking into account that incentive problems on the cost side are present the linear payment mechanism takes the form $t(C, R) = \alpha - \beta C + \gamma R$. To keep things simple in the following we are referring to a payment mechanism solely based on user charges. This means, $\alpha = 0$ and $\gamma = 1$, so the contractor bears all demand risk and gets no insurance from the government. Furthermore, we assume that the government can choose a price level p in the interval $[0, p_0]$.

According to these assumptions the contractor maximizes the uncertainty equivalent of his expected utility and his incentive constraint can be written as follows:

$$\begin{aligned}(a, e) &= \arg\max_{\tilde{a},\tilde{e}} p(d_0 + \tilde{a}) - \beta(\theta_0 - \tilde{e} - \delta\tilde{a}) - \frac{\tilde{a}^2}{2} - \frac{\tilde{e}^2}{2} - \frac{r\sigma\epsilon^2}{2}\beta^2 - \frac{r\sigma\eta^2}{2}p^2 \\ &= (p + \beta\delta, \beta). \quad (21)\end{aligned}$$

Using the above incentive constraints of the contractor by eliminating the slope of the incentive scheme β yields the following maximization problem for the government:

$$\max b_0 + ba + p_0(d_0 + a) - \theta_0 + e + \delta a) - \frac{a^2}{2} - \frac{e^2}{2} - \frac{r\sigma\epsilon^2}{2}e^2 - \frac{r\sigma\eta^2}{2}(a - \delta e)^2$$
$$\text{subject to} \quad a = p + \delta e \quad (22)$$

The optimization yields the following second–best effort levels:

$$a^{SB} = \frac{(b + p_0 + \delta)(1 + r\sigma_\epsilon^2) + r\sigma_\eta^2\delta(1 + \delta(b + p_0 + \delta))}{1 + r\sigma_\epsilon^2 + r\sigma_\eta^2(1 + \delta^2 + r\sigma_\epsilon^2)} \quad \text{and}$$
$$e^{SB} = \frac{1 + r\sigma_\eta^2(1 + \delta(b + p_0 + \delta))}{1 + r\sigma_\epsilon^2 + r\sigma_\eta^2(1 + \delta^2 + r\sigma_\epsilon^2)} \quad (23)$$

Regarding the fact that the interpretation of these terms seems to be rather complicated we will simplify the problem by setting the incentive scheme β equal to 1. It follows that $e = \beta = 1$, and so we get the following second–best quality enhancing effort level a^{SB}:

$$a^{SB} = \frac{b + p_0 + \delta + r\delta\sigma_\eta^2}{1 + r\sigma_\eta^2}. \tag{24}$$

When the incentives are only set through the price p, but β is fixed the result for a^{SB} can be interpreted as follows:

Positive externality ($\delta > 0$) When a positive externality exists it holds, that the effort level chosen is always positive:

$$a^{SB} = \frac{b + p_0 + \delta + r\delta\sigma_\eta^2}{1 + r\sigma_\eta^2} > 0. \tag{25}$$

From the basic model we already know that considering a positive externality the quality improving effort a^{SB} reduces the level of operational costs at the same time. Here, regarding the additional positive impact on the demand side, the level of a^{SB} might be even higher than in the case of bundling with a positive externality, where demand risk is ignored. Thus the argument for bundling could be even stronger, when demand risk is included in the calculations.

Negative externality ($\delta \leq 0$) In the case of a negative externality the desirability of bundling the building and operation stages depends on the extent of the additional benefits through introducing demand risk into the model. In order to make sure that bundling is preferred over unbundling the following condition has to hold:

$$\frac{b + p_0}{1 + r\sigma_\eta^2} > \delta. \tag{26}$$

This means, if the positive effect of the quality enhancing effort on the social benefit and demand dominates the negative impact on the operation cost, a positive effort level a will be chosen and bundling is better than unbundling. This result is interesting compared to the case without considering the demand side. In the basic model we have shown that in the case of a negative externality the quality enhancing effort level will be zero and bundling yields the same outcome as unbundling. In the above extended model we could see, that as soon as the demand side is included, it might be possible that even in the case of a negative externality bundling would be preferable. However, we have to underline that for now we only considered the very simple case, where $\beta = 1$. Regarding the more complicated case, where the level of β is not fixed it is much more difficult to make an exact statement about the level of a. In this case further calculations would be necessary, which for now have been ignored to keep things simple.

To sum up our results we can say that under a positive externality it still holds that bundling is the optimal choice when considering demand risk in the model and the obtained effort level is possibly even greater because of the additional positive effect of the quality enhancing effort on demand. Furthermore, we found some evidence that under certain circumstances even in the case of a negative externality it is possible that bundling dominates unbundling, since the positive impact of effort a on the quality and the demand might outweigh the negative effect on the operating costs.

4 Application to projects from the motorway sector

In the last two decades there have been experiences in many countries with PPPs in the motorway sector. However, the number of projects in Germany is relatively small. Actually, the first PPP–project for building and operating a German federal motorway ("Autobahn") relates to the A8 between Munich and Augsburg in southern Bavaria. The A8 is an important corridor in Southern Germany belonging to the Trans-European Network (TEN). Most parts of the motorway are still in prewar condition and the number of users per day accounts for 60 to 100 thousands, so it is of particular interest that the quality of the road will be improved immediately. The motorway currently has two lanes in each direction with soft shoulders. When reconstruction is complete, there will be three lanes open for traffic in each direction with hard shoulders.

The A8–project was initiated years ago, but construction did not start before last year. In May 2007 the consortium "Autobahnplus ("a+")" began its work on the approximately 37 km segment of the motorway between Augsburg/West and Palsweis. "Autobahnplus" is a consortium formed by BAM PPP, Trapp Infra Wesel (VolkerWessels), Fluor Infrastructure, Berger Bau and Egis Projects. The client is the Motorway Authority for South-Bavaria (Autobahndirektion Südbayern) on behalf of the Federal Ministry of Transport. The value of construction activities is approximately 250 million Euros. BAM PPP, Fluor Infrastructure, and Trapp Infra Wesel each have a share of 25 percent. The extension of the motorway by the consortium partners and Wayss & Freytag Ingenieurbau (BAM) is planned to be finished in December 2010. During the 30 years concession period the consortium will be responsible for operating and maintaining an additional 15 km of motorway around Munich, for a total concession length of 52 km. The outside capital needed for financing the project has been provided by the Defpa Bank (headquarters Ireland) and the Spanish Banco Santander Central Hispano, S.A. During the concession period the consortium receives the revenues from freight vehicle tolls collected on the concerned motorway. There has been also a start–up financing from the federal budget.

Now we will apply the criteria developed in the theoretical model to evaluate the A8 project from an economic perspective. First, we consider the aspect of bundling the different tasks, its advantages and disadvantages. As already shown in the model by Iossa and Martimort (2008) the choice between bundling and unbundling the tasks depends primarily on the impact of a specific quality enhancing investment in the building stage on the operating costs in the next phase. In a situation, where a positive externality between the stages can be observed, bundling of tasks always dominates traditional service provision. The decision is more difficult in the case of a negative externality. Here, considering only the negative impact of the investment in the first stage on the operating costs would lead to the conclusion that bundling is not always the best option since it yields the same result as unbundling. However, there are also other aspects worth to analyze before choosing the traditional way of procurement. Among these aspects we have to look at the demand risk associated with the specific project.

Regarding the demand risk the so–called A–model, a financing model used in the concession contract between the consortium and the Bavarian federal state plays an important role. The A–model is usually applied for the extension of federal motorways in Germany. A private partner receives a concession contract for the design, construction, maintenance, operation and complete financing of a predefined section of a motorway. The funding of the project occurs in general through user charges for heavy vehicles (> 12 tonnes), which is determined by law. Furthermore, the concession partner receives a one–time start–up financing as compensation for cars, for which no toll is paid. In contrast to the A–model the alternative F–model underlies the law concerning the building and financing of motorways by the use of private enterprise, according to which private agents receive toll payments for all types of vehicles. Considering the construction of motorways the A–model represents the more popular financing method, whereas the F–model is used rather rarely. The fact that user charges only have to be paid for heavy vehicles is one of the most important advantages of the A–model. As cars do not underlie user charges, part of the demand risk is already eliminated, since in this way switching to other alternative toll–free country roads or motorways can be avoided in the case of car drivers. Thus, regarding the amount of demand risk transferred to the private contractor only heavy vehicles have to be regarded. The consortium “a+” receives revenues directly through the toll payments from these end users, thus he also bears the whole demand risk associated with heavy vehicles. Given that risk–aversion and demand risk are in this sector usually rather small, user charges seem to be an appropriate form of payment. Transferring demand risk to the contractor raises his incentives to boost demand and increase the consumer surplus. However, the government still has to pay a higher risk–premium. Since demand levels are in this sector highly affected by the private partner's actions, it is nevertheless desirable that a high amount of the demand risk is borne by the contractor. The analysis above also suggests, that a PPP is often preferable, when the quality of the infrastructure has a strong impact on the service quality, and when demand for the service is stable and easy to forecast. This applies to the transport sector in general and to motorways in particular. It follows, that PPPs in this sector promise significant efficiency gains.

Another crucial point relates to the contract length. This aspect is not only interesting in terms of demand risk allocation to the private contractor, but also regarding the allocation of construction risk and private finance. In general it is argued that in sectors, where demand risk is relatively low, contracts should be longer. This again applies to the motorway sector. The theory is also supported by the example of the A8: the contract period is fixed for 30 years, which could also be interpreted as a sign, that demand risk is rather low in this case. Another reason to increase contract length can be that financially free–standing projects bring additional costs. To allow the firm to recoup his initial investments the contract has to be longer. As we already mentioned, in the case of the A8 between Munich and Augsburg the concession period takes 30 years, including the period of the extension of the motorway. Since the contract period includes the construction period as well, it follows that the endogenous risk associated with the length of the construction period is also transferred to the contractor. This gives the private partner a higher incentive to complete the extension as soon as possible.[8] Furthermore, the fact that the private partner must also provide at least partly the financing of the project, he suffers the consequences of a delay in the construction even more. This strengthens his incentives even further to finish on time and on budget.

Our next point relates to the aspect of external finance. In the case of the A8 motorway external capital has been provided by two banks, by the Defpa Bank (headquarters Ireland) and the Spanish Banco Santander Central Hispano, S.A. External finance of

[8]See also Sadka (2008).

PPP–projects has been often criticized by experts for damping the consortium's incentives in many ways, since it has to share its profits with the external investors and so the advantages from bundling of tasks diminish. On the other hand, proponents argue that especially in the case of very complex projects specialized outside financiers can lead to more effective monitoring and so economies of scale can be realized. However, it is not only external capital that is being used for the project. The federal government also provides a one–time start–up financing for the consortium, so that the initial capital investment is lower, which in turn decreases the amount of investment required from the consortium itself and so militates in favor of a PPP.[9].

To sum up, a PPP regarding the A8 project between Munich and Augsburg seems in general to be desirable, since demand risk in the sector is rather low, the quality of service is quite precisely definable, and also if initial investment is high the relatively long contract period ensures that investments of the private partner can be recouped. Contract length and private finance provide additional incentives to complete the construction on time and on budget. Furthermore, external finance might have a negative impact on the incentives of the private contractor indeed, but this negative effect can be offset by better monitoring and by the resulting economies of scale. Here, even in case of a negative externality bundling seems to be desirable, since other factors with positive impact on the incentives of the private agent outweigh those negative ones. This all leads to the conclusion that efficiency gains from the A8 motorway project are possibly large enough to compensate for any other problem resulting from the partnership between the consortium and the Bavarian federal state. Although so far little experience is available relating to PPPs in the German motorway sector, the existing projects show relatively strong evidence that partnerships work well in this field, so further projects are planned and some of them are already in progress.

[9]See also Dewatripont and Legros (2005)

5 Conclusion

Public Private Partnerhips become more and more common for the provision of public services or infrastructure. From an economic point of view, one core characteristic of public private partnerships is the bundling of some or all of the different stages of a project, namely design, building, operating and financing. A closely linked second aspect is the transfer of risk and responsibility to the private partner. Bundling may be preferable if non–contractible investments in one stage influence costs or benefits in another stage. To provide appropriate investment incentives, the contractor's compensation must depend on costs, output and/or service quality. Compared to traditional procurement, a PPP therefore faces more cost and demand risks.

In our theoretical analysis we discussed how positive and negative externalities and the risk parameters affect the desirability of two specific forms of PPPs: A PPP that bundles building and operating and is only imposed to cost risk and a PPP that also involves financing and must face demand risk as well. We showed that the latter institutional design is likely to be optimal if quality enhancing investments in the building stage (i) negatively affect operating costs, (ii) have a positive impact on demand and (iii) demand risk is relatively low. To show the usefulness of our approach, we applied our results to a specific project — the six-lane development of the A8 motorway from Augsburg to Munich. We argued that the chosen institutional design is quite likely to be appropriate given the specific circumstances of the project.

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