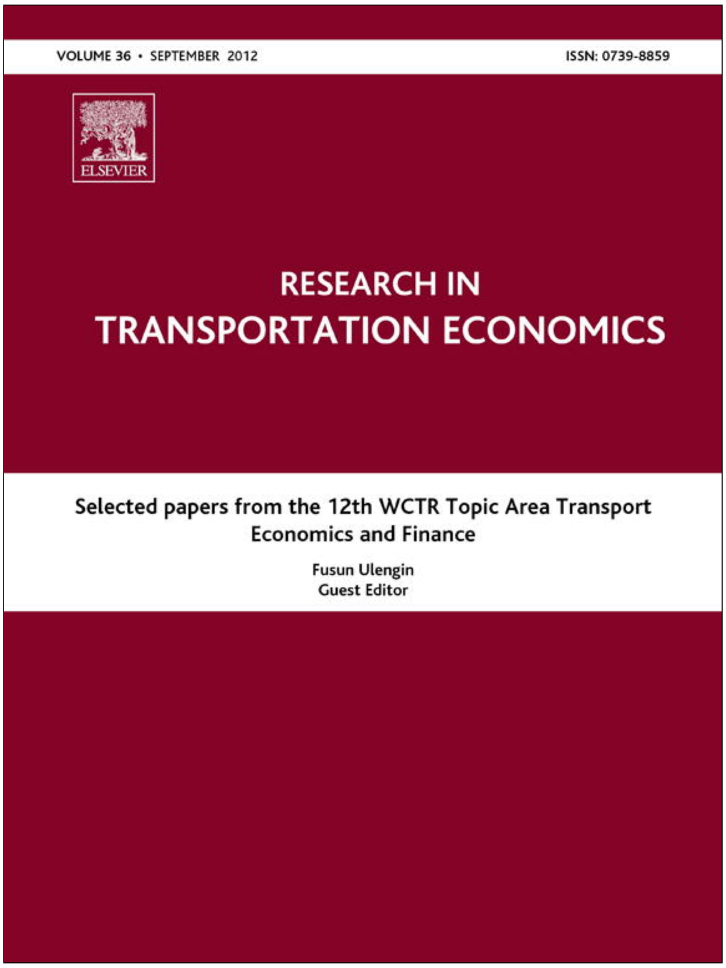
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The use of PPP's and the profitability rate paradox

Alain Bonnafous

Laboratoire d'Economie des Transports, University of Lyon, France

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A B S T R A C T

Over the past twenty years growth in the use of PPPs for new infrastructures has signalled a significant change which completely redefines the issues of public economics in the field of transport policy. This paper concerns the optimal casting between public sphere and private operators. The analysis is based on relationships linking for each project the subsidy rate, the internal rate of return (IRR) and the additional IRR provided to the operator by subsidies. The need for subsidy appears as an increasing function of this additional IRR. Nevertheless, the gradient of the curve decreases in a marked manner. This concavity has some policy oriented consequences.

A paradoxical consequence of the concavity of the subsidy function concerns the choice between public or private operators. Because the private operator's charges include the remuneration of his own capital and therefore allow him to make a profit, the choice of a PPP needs more subsidies if we assume that the Internal Rate of Return (IRR) for the project will be the same for both a public and a private operator. The PPP option is only justified when this assumption is not relevant and under specific conditions.

Nevertheless, the additional cost of the private issue is decreasing when the intrinsic profitability rate of the project is itself decreasing. Moreover, when the hypothesis of equal efficiency is removed, i.e. when the private sector is more efficient, the lower the profitability of the project, the stronger the interest for public financing of using a private operator.

1. Introduction

During the twentieth century, the trend that seemed to be emerging in many countries was towards a certain distribution of roles whereby transport operations were assigned to the private sphere and infrastructure to the public sphere. From the nineties, however, growth in the use of PPPs has signalled a significant change which completely redefines the issue of infrastructure funding.

This new trend has been systematically tracked in developing countries and transition economies by the World Bank. The Bank (2009) reported 1147 projects in the transport sector of 81 countries involving private operators from 1990 to 2008. These investments in transport infrastructure nonetheless amounted to 232 billion dollars. This trend is also apparent in the developed economies, although initiatives in this area remain still limited for transportation.

These trends obviously reflect economic rationales which, although they may sometimes prove controversial, can draw on an extensive literature. Among the reasons that may favour this private sector involvement, this article will be interested particularly in one of them, namely the scarcity of public funds, either for the public sector operator taking on the project or the nation as a whole.

If the objective function of a private operator is the profit of the operation, a profit that is obviously discounted and if appropriate enriched by taking uncertainty into account, the government's objective function is the discounted variation in social welfare that takes into account, in addition to the operator's profit, factors such as public spending, user surpluses and environmental impact. In a previous paper in this journal (Bonnafous, 2010), we observed that many factors can affect both these objective functions differently, for instance infrastructure pricing, which is in principle not the same depending on whether it optimises the operator's profits or social welfare. More generally, the purpose of this previous article was to show that all the standard tools of public economics need to be reconsidered when PPPs are implemented. Thus we need to place clearly the subject of the present article with regard to the precedent. To that effect we will consider five levers among the government's controls over a transport system.

Fig. 1 represents in the simplest possible terms the functioning of a transport market (passenger or freight) such as a continental (or regional or urban) transport market. At the heart of the market

E-mail address: Alain.Bonnafous@let.ish-lyon.cnrs.fr.

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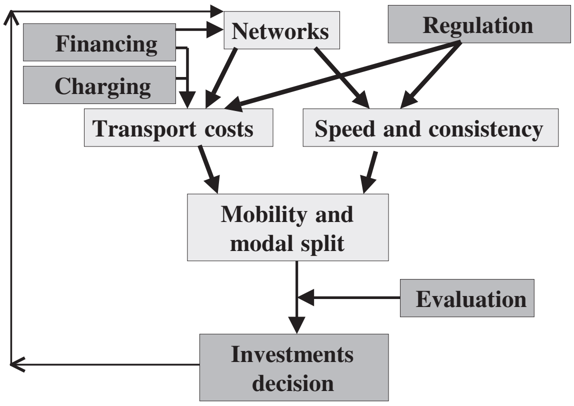

Fig. 1. Government's controls over a transport system.

mechanisms is the supply of transport, which determines the mobility levels of passengers and freight provided by each mode. For centuries, the two main factors of intermodal competition have been prices and speed – the latter needing to be considered broadly, encompassing, for example, frequency or reliability.

For each mode of transport, the prices and speeds on offer are clearly dependent on the quality of infrastructure networks and how they are operated. Here we see the role of government's controls over the system – controls shown above in grey-shaded boxes. The first two means of control, which affect the relative prices of competing modes, are *financing methods* (for infrastructure and operations) and *charging for the use of infrastructure*. Another means of control that also affects relative prices, but speed as well, is *regulation* – a term that we use very broadly to encompass labour and safety matters as well as the general organisation of transport markets, including those for infrastructure supply and demand, in which the degree of both regulation and competition can vary.

The traffic levels resulting from this competition, reflecting the intensity of use of the transport networks, will depend on the efficiency of the corresponding modes. In sum, it is this relative efficiency that will determine the needs for new infrastructure and, in particular, a project's socio-economic and financial returns. As a result, the diagram shows as means of control the *evaluation of investments* and the *investment decision itself*, which should be used consistently with evaluation. It is these investment choices that over time will shape the development of competing networks, thus "closing the loop" of the system.

In this simplified diagram, transport is shaped fundamentally by market mechanisms, but mechanisms that remain in the hands of government, which exercises the five major means of control cited above. Yet if this diagram is to have any relevance, it is clear that one must factor in all of the means of control and ascertain whether there is a good strategic fit between them, in terms of coherent PPP's implementation, insofar as they are exercised jointly by public authorities. Each means of control must therefore be examined from two standpoints: how they must be used in order to optimise the system; and how they interact with the other means of control comprising the system.

The previous article concerned some consequences of a PPP device on these five means on control. It began by showing that when projects are financed by both users (toll revenues) and taxpayers (subsidies), it is socially beneficial to plan these investments on the basis of the net present value (NPV) provided by each unit of public money invested. This NPV/subsidy ratio must obviously be higher than the public-funding scarcity coefficient or else the investment would destroy more wealth than it would produce. This first result concerned specifically the couple of means of control "evaluation" and "investments decision".

The second result concerned the question of the optimal toll. From the point of view of the private operator, it is obviously the toll which maximizes the net revenue. From the point of view of the public authorities, to increase the level of tolls can lower the subsidy but it has an opposite effect on the user surplus. It is advisable to distinguish two cases, as we consider an isolated project which will be built in every case, or as we consider a program of projects.

In the case of an approved project considered in isolation, we showed that the optimal toll depends upon the public-funding scarcity coefficient. If there is no scarcity, the optimal toll is zero. As public-funding becomes scarcer, the optimal toll draws closer to the toll that optimises revenue.

In the case of a programme of several projects subject to budget constraint, we showed that the optimal toll no longer depends upon the public-funding scarcity coefficient and that there are several scenarios depending on the relative values of the maximum revenue and the total cost of the project:

- when, whatever the toll, revenue can no longer cover over half of the cost, it is socially beneficial to choose not to levy any toll;
- when there is a toll that covers the total cost, the operator may be left free to set it at the level he sees fit, with the issue of how the profits are to be shared between the franchisee and the franchisor being settled separately;
- when the maximum revenue of the project falls between half and all of the total cost, the value of the toll that maximises the welfare function is lower than the revenue-maximising toll and must therefore be set for the private operator by government.

Thus, the partnership contract must be given a different content in these three cases of optimal pricing. This second result concerned specifically the couple of means of control "financing" and "charging". However, as far as this result has consequences on the rules of pricing planned in the contract, it also concerns the means of control "regulation".

Nevertheless, this previous article did not handle the preliminary regulation problem which is exactly the object of the present paper: either to implement a PPP contract or use the usual public device. The aim, in short, is to determine the conditions under whose the use of a private partnership can reduce the burden on public finances compared with the use of a public enterprises whose debts are guaranteed by the State.

2. Does a PPP relieve the need of subsidy?

Once again, we consider this means of control names above "regulation" in the broad sense, i.e. encompassing all of the dimensions that govern the sector's operations, including institutional mechanisms. The competitive orientation of these mechanisms may have greater repercussions on the funding of the transport system, particularly on the public finances.

In order to present the problem clearly, we will not consider the full diversity of situations in which private investors could be involved, but just two stylised cases opposing the "public" alternative and the "private" alternative.

2.1. The need of subsidy in two stylised cases

These cases are characterised by the following restrictive hypotheses:

- In the "public" alternative, it is assumed that the operator in charge of the project is a non-profit company which nevertheless has to achieve a balance between the project's investment and operating costs (including financial charges) by using

revenues from fares (and perhaps tolls or even shadow tolls). If the project's finances are not balanced, it is assumed that the deficit will be made up by subsidies from the public authority. The level of subsidies is agreed on the base of an *ex ante* cost-benefit analysis and is intended to guarantee a balance between future expenses and revenues.
- In the "private" alternative, as the operator in charge of the project is a private company, the mechanism is the same except that expenses must also include the operator's profit.
- Assessments and interest rates are inflation-adjusted.
- The financial internal rate of return (IRR) is temporally assumed to be the same for both the public and private alternatives for a given project. We know this hypothesis is not really true (Dewenter & Malatesta, 2001) but it cannot be eliminated at this first stage in our analysis.

With reference to these considerations, *it is assumed that a public operator will implement a project if the expected IRR covers the market interest rate plus a risk premium* which takes account of the uncertainties that necessarily affect assessments of, for example, costs and future traffic and revenue. Thus, with a market interest rate of 4% and a risk premium of 4%, the minimum IRR will be 8%. If the IRR of the project is any lower than this the public operator will require an additional subsidy in order to reach 8%.

For the same project, *a private operator has to cover an interest rate which is assumed to be the same, plus approximately the same risk premium* (which may also include an additional amount to cover uncertainties about the stability of the country in question) *and also add a profit margin* – let us say 4% more. This means that an additional subsidy will be required for any IRR below 12%.

In both cases, we are very near the standard notion of Weighted Average Capital Cost (WACC), but we prefer to use the notion of target IRR. This analysis would seem to suggest that there is a range of IRRs for which the private alternative would require larger subsidies. Under real circumstances, the challenge facing the private operator is of course to achieve a higher IRR through better project management, but as stated above we shall explore this possibility later and we need beforehand to provide a formal relationship between the need for subsidies and the level of the IRR.

2.2. Relationships between IRRs and subsidies

In order to explore the effect on the internal rate of return of subsidising the capital cost, suppose a standard case (Bonnafous, 2002) in which the capital cost C is incurred at an annual rate $c = C/d$ between the dates $-d$ and 0. When the project comes into use at time 0, the annual profit rate (revenues less operating and other ongoing costs) takes the form $(a + bt)$. We now introduce this further notation:

α is a discount rate which may be used to calculate the Net Present Value (NPV),

α_0 is that value of α which makes the NPV (of the unsubsidised project) equal to zero – in other words, α_0 is the internal rate of return,

τ is the subsidy rate, expressed as a percentage of c,

δ is the increase in the IRR that results from the subsidy rate. τ – that is to say, for a subsidy rate τ, the IRR becomes $(\alpha_0 + \delta)$. If we recognise all benefits and costs up to a terminal date T, then

$$\mathrm{NPV} = \int_{-d}^{0} -c \cdot e^{-\alpha t} \cdot dt + \int_{0}^{T} (a + b \cdot t) \cdot e^{-\alpha t} \cdot dt \quad (1)$$

To simplify the calculations – with little empirical effect – now set the terminal date to infinity. Then Equation (1) becomes

$$\mathrm{NPV} = \frac{1}{\alpha}\left[c\left(1 - e^{\alpha d}\right) + a + \frac{b}{\alpha}\right] \quad (2)$$

The IRR α_0 of the unsubsidised project is therefore given by:

$$c\left(1 - e^{\alpha_0 d}\right) + a + \frac{b}{\alpha_0} = 0 \quad (3)$$

Note that for this unsubsidised project, α_0 is an implicit function of the four variables: a, b, c and d. When the subsidy τ is applied, Equation (3) becomes

$$(1 - \tau)c\left(1 - e^{(\alpha_0 + \delta)d}\right) + a + \frac{b}{\alpha_0 + \delta} = 0 \quad (4)$$

If we think of the situation as one in which we want to find the subsidy rate τ that yields a specified IRR of $(\alpha_0 + \delta)$, then Equation (4) may be written as

$$\tau = 1 - \frac{a(\alpha_0 + \delta) + b}{c(\alpha_0 + \delta)\left(e^{(\alpha_0 + \delta)d} - 1\right)} \quad (5)$$

Here, τ is expressed as a function of six variables. However, these are not all independent, because α_0 depends on a, b, c and d, according to Equation (4).

This function brings a central result which is clearly the relationship between τ and δ. However, Equation (5) also shows that this relationship obviously depends on the values of the parameters c, d, a, b and, of course, α_0, which characterize the economics of the project and which are moreover linked together by Equation (4) which established the IRR of the project α_0. If we wish to represent Equation (5) we therefore need to keep some of these 5 parameters constant and vary just those whose role we wish to demonstrate. This is the well-known technique of abacuses illustrated by the family of curves shown in Fig. 2. It is drawn for the numerical case given by $c = 100$, $b = 1$, $d = 5$ together with alternative values of a chosen so that as a increases from one value to the next, α_0 increases by 0.4 percentage points. Each curve corresponds to a particular value for a, and shows how the required subsidy τ increases as we increase the IRR from α_0 to the target IRR, $(\alpha_0 + \delta)$.

It is quite natural for the need for subsidy to be an increasing function of the additional IRR which the operator must receive. However, the gradient of the curve decreases in a marked manner. This concavity has been demonstrated in a previous paper (Bonnafous & Jensen, 2005) is a counter-intuitive result: it means that the first differences between the targeted IRR and the IRR of the operation can be extremely costly.

In some cases, the choice of a private operator could be expensive for the public authorities. Thus, Fig. 2 shows that a project with an initial IRR α_0 of 8%, and which could therefore be possible for a public sector operator without a subsidy (with the hypotheses set out in paragraph 2.1) would need a subsidy of 45% to raise its IRR to 12%.

The shape of the curve, in particular its downward gradient, nevertheless has an other consequence. The larger the margin by which the targeted IRR exceeds the IRR of the project, the lower the marginal cost to the public purse of an increase in this targeted IRR: thus, in the case where the profitability of a project is 4% (shown in bold on Fig. 2), increasing the targeted IRR from 8% to 12% will require the amount contributed by public finance to be increased by 13% of the cost of the project. Furthermore, an increase from 12% to 14% would require an additional subsidy of only 3%.

We therefore arrive at the following surprising paradox: *the additional cost for public authorities who use a private operator is less for projects whose intrinsic profitability is lower.*

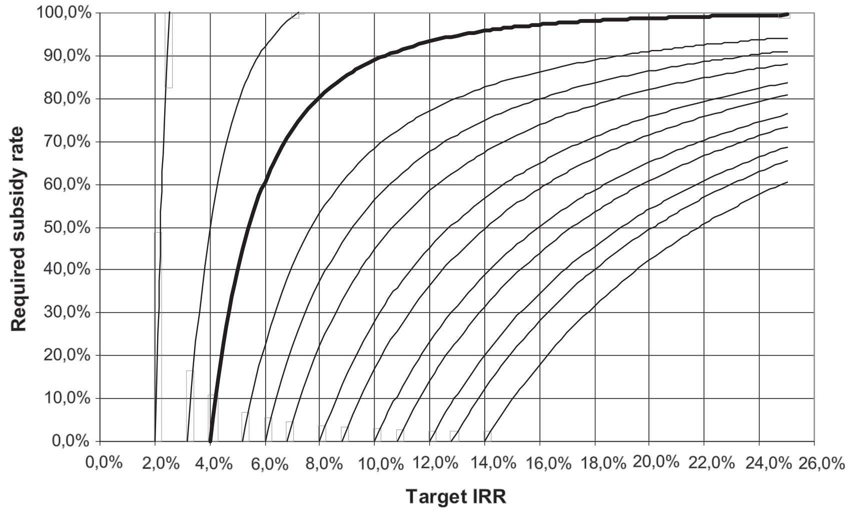

Fig. 2. Relationship between the subsidy rate and the target IRR (Family of curves based on c=100, b=1, d=5 years and a variable).

This finding ties up with the observation, which is also paradoxical, that *private company involvement in the development of major transport infrastructure is increasing at a time when the projects that remain to be constructed are considerably less profitable than those that are already in service* (at least in European countries). The theoretical paradox does not, of course, explain the empirical paradox, as each experience of privatising public facilities takes place within a specific historical context. There is obviously a difference between the historical context of major sub-Saharan railway lines in Africa and that of a Californian toll motorway. Nevertheless, the theoretical paradox explains why the shift towards privatisation should result in fewer financing difficulties for the public authorities than might be suggested by too summary an analysis.

It obviously remains for us to add to these considerations the dimension to the public–private partnership issue that we have until now avoided, namely, the respective efficiency of public and private enterprises.

2.3. When the private company is more efficient

It would be fair to assume that private operators are capable of improving the internal rate of return of the operation, *either though better control of operating costs [improvement of a and b in* Equation (3) *which determines α_0], lower investment costs (lowering of c), short construction lead times (reduction of d) or a combination of these profitability factors*. By way of a simple illustration, we shall assume that the initial IRR α_0 is thereby improved by 2 per cent.

As we vary the value of the IRR α_0, we obtain the subsidy rates that are shown on Fig. 3 below, with the hypothesis described above, namely that the "target IRR" is 8% for a public sector operator and 12% for a private sector operator.

We have therefore used a set of parameters which is more specific still than that which provides the basis for the nomogram in Fig. 2. We have done this by setting thresholds for the target IRRs thereby formalising, in an admittedly crude manner, the effect of efficiency. Nevertheless, the plots are merely the outcome of the concave nature of the subsidy rate function.

This graph shows, for the set of parameters in question, that we can identify three distinct zones of IRR values. These relate to three fairly well-contrasted choice situations:

1) On the right hand side of the graph, where the rates of return are of the same order or higher than those targeted by public sector operators, public sector finance must lose as the result of the use of a private sector operator. When the loss is limited, such use may nevertheless be justified on the grounds of the overall increase in productivity that affects the economy as a whole as a result of the difference in efficiency.
2) On the left hand side of the graph, where rates of return are very low, the effect of the difference in efficiency is considerable, but we are not far removed from the situation in which the scheme may have an insufficient social return, casting doubt on the project's validity, at least in the form in question. In the case of motorways, for example, it may be wiser to abandon the idea of constructing a toll motorway in favour of a four-lane dual carriageway which has less demanding and less expensive characteristics (if only because it is possible to use some or all of the existing route). However, if its construction is justified on the grounds of socio-economic profitability it will be less costly for the public purse to let a private operator run it.
3) There is a point of transition between these zones at a certain value of α_0 below which the use of a private sector operator reduces public expenditure (for the reader's information this point is located at an α_0 value of 5.2% for the case we have

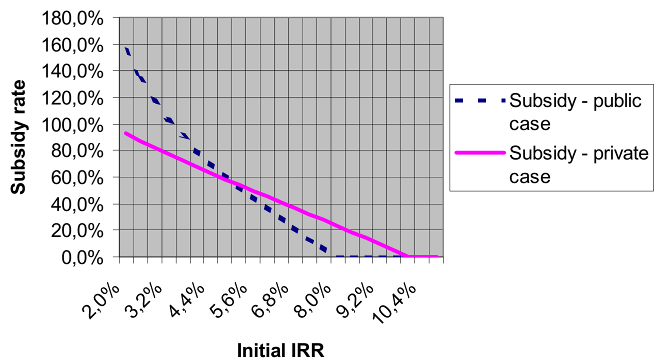

Fig. 3. Subsidy rate as a function of initial IRR α_0 on the assumption that the private operator is more efficient (Target IRR of 8% for the public operator and 12% for the private operator, initial IRR: for public operator = α_0, for private operator = α_0 + 2%).

simulated). In this case the criterion of social return dictates the best choice for society.

We must make it plain that the existence of *this transition is not an inevitable consequence of the concavity of the need for subsidy function*: there are obviously some values for the parameters for which the function is higher (or lower) at all points for a private sector operator. *What we call the paradox of financial profitability only means that, when there is a point of transition for a subset of the possible values of a, b, c and d and of the target IRRs of the two types of operator, the interest of a PPP is higher when the financial IRR is lower and vice versa*. In any way, it is clear that the decision to choose either the public issue or a PPP requires for each project a specific appraisal in order to compare the needs of subsidies.

The concavity of the need for subsidy function has more an important consequence when it is a question, either of a single project but a program of several projects. Indeed, projects with low profitability require a rate of subsidy which increases very rapidly with the IRR it is necessary to provide the operator, even a public sector operator. This means that *under a given budgetary constraint the order in which projects are constructed which gives priority to the most profitable projects could significantly strengthens the leverage effect of unit subsidy and therefore the rate at which infrastructure will be constructed*. The value of this study is not that it confirms this elementary recommendation for public economics but that it demonstrates that, because the concavity of the subsidy function, the effect of any failure to make public investment despite low profitability is far greater than straightforward economic common sense would suggest.

3. Some policy oriented conclusions

It must be stressed once again that the findings suggested by the equation that links the subsidy to an improvement of the IRR of a project are only approximations based on specific hypotheses. Each of these hypotheses needs to be removed, or at least questioned, if we are to establish within what ranges our conclusions are valid.

The formalization of the problem which we have considered is quite appropriate for this purpose. It is thus fairly easy to construct abacuses of the type shown in Fig. 2 with different cost/benefit time series plots. It is, for example, possible to vary the intrinsic IRR of projects α_0 by fixing the cost, the duration and the net profits on coming into service *a* and varying *b*, which amounts to imagining changes in demand of varying intensities. Similarly, it is also straightforward to modify Equations (4) and (5) by hypothesizing of an exponential instead of a linear increase in demand.

However, the transformation of an increase in cost into a saving (the transition we have described above) is not automatic but requires particular combinations of parameter values. The conditions under which such a transition point exists are still to be explored, probably in a different manner from that we have used in Section 2. By assuming that better efficiency will increase the initial IRR of the operation by 2% whatever its value, we have performed a rather rash proportional transformation: depending on whether the effect of efficiency is, for example, the result of construction works being performed more quickly or greater commercial efficiency, there is little chance that it will raise the IRR by the same amount for all the different values of the initial IRR. I have done this only because the large number of parameters involved means that abacuses are ineffective.

In order to be able to use simulations and abacuses once more it is necessary to reduce the parameter ranges, that is to say determine the intervals of variation which it is pertinent to combine. Once the empirical research for this has been done it will be possible to run through the pertinent sets of simulations. We can feel fairly certain that the outcome of the various simulations will differ in a marked manner depending on the economic, financial and societal conditions that are specific to each national or regional policy and each sector of activity, whether within the transport sector or outside it.

It is nevertheless the case that the relationships that have been established and shown here for a specific case suggest three important lessons for transport policy with regard to the choice of investments and public–private partnerships:

1) If the private sector operators are not more efficient than public sector operators, it is always more expensive for the State to place a public infrastructure under private sector management. *For projects whose IRR approaches or just reaches the rate of profitability required for a public sector operator, the choice of a private sector operator can generate large additional costs for the public authorities*, unless the difference between the required IRRs can be eliminated by the much greater efficiency of the private sector operator.
2) *When a project is selected in spite of a low IRR, the lower this IRR, the lower the additional cost of using a private operator*. In this case, which is frequent in urban areas because of the scale of externalities, the paradox of profitability should be considered.
3) *If the private operators are more efficient, instead of an additional cost there may be a saving, and this is more likely to occur the lower the financial profitability of the project*. It is therefore quite understandable for private sector operators to be offered the management of schemes whose profitability is very low, as doing so may reduce public expenditure and raise the social return of the scheme.

In all the cases it is clear that the coherence between the five means of control which we distinguished in our introduction must be based on a common objective function i.e. the welfare gain brought by every spent public Euro. Resorting to a PPP or not, evaluation and ranking of projects, financing and charging rules are nothing else than the various facets of the same problem, that of the optimal transport policy.

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