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Public Private Partnership for maintenance activities – System boundaries for a life cycle oriented economic efficiency analysis

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ABSTRACT

Public Private Partnerships are not just expedient for building new roads, bridges or buildings; they can also be put to good use for operating existing infrastructures. The involvement of private partners in the maintenance of street networks, in particular, can potentially improve cost efficiency.

Unlike new construction projects, changing the maintenance of existing streets creates additional difficulties in terms of assessing the economic efficiency of such a measure. These difficulties relate, above all, to defining the boundaries of the system in question in terms of both time and content. The model for analyzing the economic efficiency of Public Private Partnerships in street maintenance that has been developed by the Institute for Construction Engineering and Management at ETH Zurich offers a structured approach to obtain a clear and reliable analysis. Particular attention was paid to defining the system boundaries. This paper outlines the fundamental process for analyzing economic efficiency, together with various alternatives to define self-contained system boundaries.

KEYWORDS: Public Private Partnership, Economic Efficiency Analysis, Net Present Value, Street Maintenance, System Boundaries

1. INTRODUCTION

The challenge of coping with the growing demands on the public infrastructure with declining budgets is forcing the public sector to search for new models, not only for financing, planning and building, but also for operating and maintaining their infrastructure. The fundamental principle of public sector service performance and commitment is still, however, the need to guarantee taxpayers "value for money" (HM Treasury, 2006). As such, new delivery and service provision forms, such as Public Private Partnerships, can only be used to perform public services if their economic efficiency has first been analyzed.

In the process of comparing economic efficiency, the qualitative and quantitative opportunities and threats of a Public Private Partnership for the public sector are analyzed and combined into an overall evaluation of the alternatives in question.

The fact that the public sector is already ensuring the maintenance in the beginning and will have to continue performing certain tasks makes it essential to clearly define the system boundaries in terms of content and time. Only rigorous, self-contained system boundaries guarantee a reliable assessment of the economic efficiency of the two delivery alternatives.

This paper begins by outlining the fundamental process of analyzing the economic efficiency of the various forms of performing street maintenance. The specific requirements for the definition of the system boundaries are derived from this basis, and subsequently various alternatives to defining self-contained system boundaries developed.

2. STATE OF RESEARCH

The fundamental process of analyzing economic efficiency has been sufficiently researched, especially in terms of investment budgeting, and can be studied in various written papers (Hirst, 2001; Newnan et al., 2004). Although the decision as which form of delivery is economically the most efficient is based on these principles, it also places further demands on the process of analysis and on the definition and delimitation of the system in question. Most publications do not pay sufficient attention to this issue, which results in mistakes being made during practical implementation that can fundamentally distort the result of the economic efficiency analysis.

3. RESEARCH METHODOLOGY

A model for evaluating the economic efficiency of public sector performance (non-investive) and performance by a private partner is presented as the basis for comparing the economic efficiency of two alternative forms of delivery. The hermeneutic research paradigm with the constructivist research approach for structuring socio-technical structures is applied as the scientific base of the NPV economic efficiency model.

Triangulation is used to validate and prove the realizability of the logical-deductive model. The real systems (Public Sector resp. service provision PPP of communal street maintenance) are separated into content and time structures and interactions based on empirical analysis using the system theory developed by Bertalanffy, which makes it possible to describe the mathematical function of the real, organized complexity at theoretical level and to verify the input-output relationship using realizability tests (Girmscheid, 2004).

4. PROCESS OF ANALYZING ECONOMIC EFFICIENCY

The model offers two alternatives for ensuring operational and structural street maintenance. Current practice, which therefore forms the benchmark for comparison in the model, is for the local authorities - as the owners of the street network - to perform the maintenance works themselves. The analyzed alternative is to commission a private enterprise to perform the maintenance works in the form of a Public Private Partnership. The model is based on the assumption that the private contractor will perform operational and structural maintenance over a defined period. The street remains, however, the property of the public sector, which continues to be responsible for preservation measures and for any new construction or conversions.

The economic efficiency is analyzed in two steps, comparisons of economic efficiency I and II (see Figure 1). As a first step, the Public Sector Comparator is calculated, based on the expenditure that would be incurred if the public sector were to continue performing street maintenance. This serves as the basis for comparison for evaluating a service provision PPP in both comparisons of economic efficiency. Performance of street maintenance should only be changed if the service provision PPP is cheaper overall (Girmscheid, 2006).

The comparison of economic efficiency I should be performed at an early stage to clarify whether changing street maintenance to a service provision PPP offers any savings potential. If this is not the case, the process should be stopped, and any unnecessary expenditure on planning and tenders avoided. Since no bids are available from the contractors when comparison of economic efficiency I is performed, a forecast needs to be drawn up of the anticipated expenditure relating to a service provision PPP.

If the comparison of economic efficiency I reveals that a service provision PPP could produce cost savings, the requisite works can be put out to tender. The comparison of economic efficiency II proves the economic efficiency based on the bids submitted by the contractors.

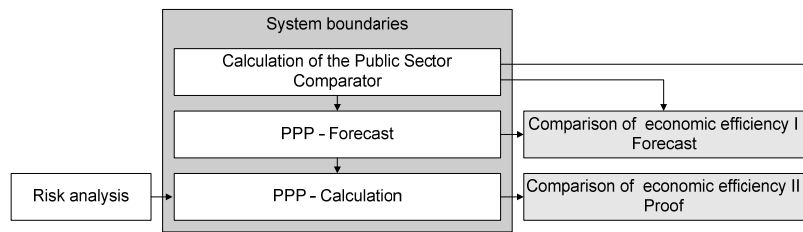


Figure 1 Process of analyzing economic efficiency

5. NPV CALCULATION

Unlike the usual definition of Net Present Value as the balance of expenditure and income (Newnan et al, 2001), the Net Present Value of a delivery form is calculated inversely:

$$NPV_{t_B} = \sum_{t=1}^n \frac{E_t - I_t}{(1+q)^{(t-t_B)}} \quad (1)$$

NPV_{t_B} = NPV relative to the reference point in time t_B

E_t = Expenditure in year t

I_t = Income in year t

q = Discount rate

t_B = Reference point in time

This inverse definition was chosen because local authority expenditure always exceeds income in street maintenance. Regular income is not generated, income is only generated in special cases, e.g. through sales. In this case, the Net Present Value of a delivery form becomes positive when expenditure exceeds income.

6. CALCULATING THE PUBLIC SECTOR COMPARATOR

The calculation of the Public Sector Comparator (PSC) provides the public sector with a reference value for delivering street maintenance that can be used to evaluate the efficiency of a Public Private Partnership (Merna and Owen, 1998). It corresponds to the discounted aggregate of all expenditure related to the public sector performing the works itself (Jacob, 2003).

In order to obtain a meaningful result, the expenditure over the last five years should be used as the basis for calculating the PSC. Based on the figures collated in the past, mean values can be derived for the individual groups or types of expenditure and projected into the future using cost increase factors. The local authority expenditure (if it performs the works itself) forecast for the individual years of a possible service provision PPP are discounted to a reference point in time.

Structured by main groups of expenditure, the Public Sector Comparator is:

$$NPV_{t_B}^{PSC} = \sum_{t=1}^n \frac{E_t^{PSC,Adm} + E_t^{PSC,BY} + E_t^{PSC,OpM} + E_t^{PSC,StrM} + P_t^{PSC,Proj} + R_t^{PSC}}{(1+q)^{(t-t_B)}} \quad (2)$$

$NPV_{t_B}^{PSC}$	= NPV of PSC performance relative to t_B
$E_t^{PSC,Adm}$	= Administration expenditure in year t
$E_t^{PSC,BY}$	= Building yard expenditure in year t
$E_t^{PSC,OpM}$	= Operational maintenance expenditure in year t
$E_t^{PSC,StrM}$	= Structural maintenance expenditure in year t
$P_t^{PSC,Proj}$	= Project expenditure in year t
R_t^{PSC}	= Risk costs in year t

7. FORECASTING THE NPV OF PPP DELIVERY

During the course of the research project on which this paper is based, three differentiated alternatives to forecasting the Net Present Value of PPP delivery were developed (Girmscheid, 2006). To this end, efficiency factors were estimated as lumps sums or to differing levels of refinement. The multiplication with these factors enables the derivation of the probable expenditure arising from a service provision PPP from the former local authority expenditure.

8. CALCULATING THE NPV OF PPP DELIVERY

For purposes of the comparison of economic efficiency II, the anticipated expenditure in the case of a service provision PPP is calculated on the basis of the contractors' bids that have meanwhile been submitted.

The efficiency potential of a PPP will not emerge in full right from the start once the street maintenance has been changed. On the one hand, there will be additional expenditure, e.g. transaction costs, while on the other hand, the former costs, especially for staff or equipment, cannot be reduced immediately. As such the analysis covers two long-term phases, each of which relates to the complete term of a PPP contract (see Figure 2):

- 1st long-term phase: Separated into an establishment phase, where additional expenditure and transition costs are incurred, and a routine phase
- 2nd long-term phase: Only a routine phase, transition costs are no longer incurred

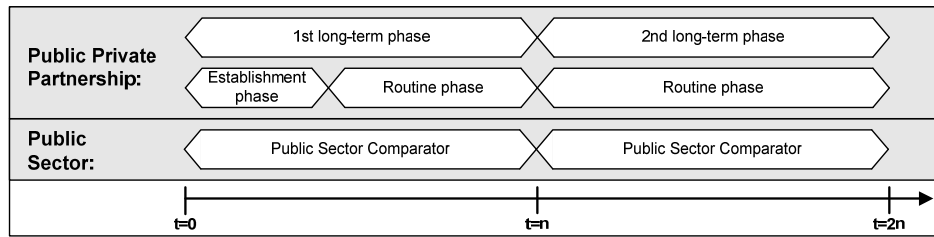


Figure 2 Comparison of economic efficiency over two long-term phases

Street maintenance should only be changed if the service provision PPP proves to be cheaper over both long-term phases than the Public Sector Comparator.

Figure 3 shows the structure of payment streams over both long-term phases.

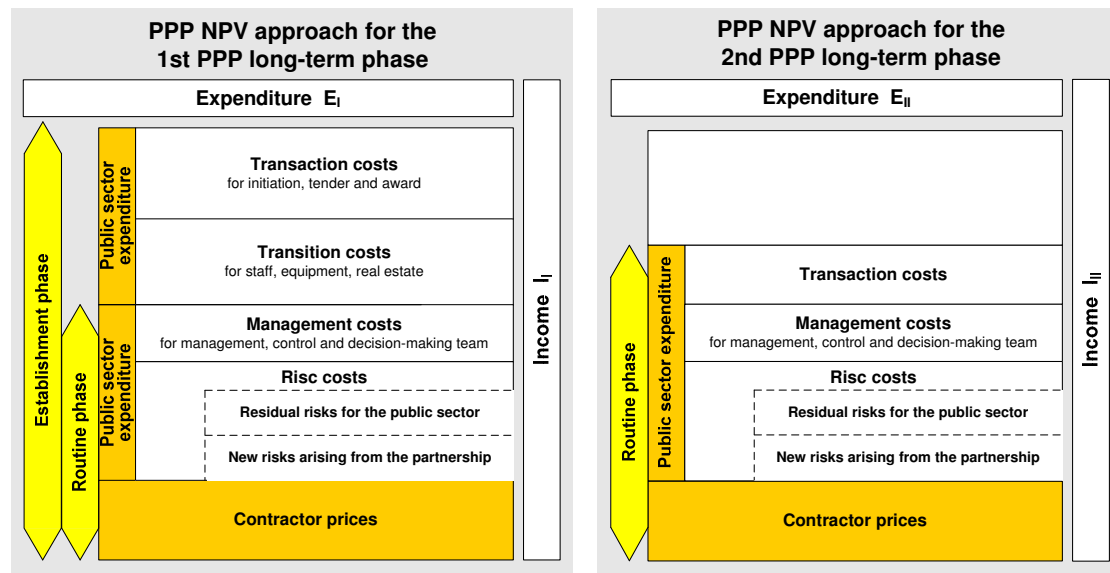


Figure 3 Structure of payment streams of PPP delivery in the 1st and 2nd long-term phases

The Net Present Values for the 1st and 2nd long-term phases are:

$$NPV_{t_B}^{PPP,I} = \frac{E_0^{PPP,TrAction}}{(1+q)^{-t_B}} + \sum_{t=1}^n \frac{E_t^{PPP,Trans} + E_t^{PPP,Man} + R_t^{PPP} + P_t^{PPP,Contr} - I_t^{PPP}}{(1+q)^{(t-t_B)}} \quad (3)$$

$$NPV_{t_B}^{PPP,II} = \frac{E_0^{PPP,Trans}}{(1+q)^{-t_B}} + \sum_{t=1}^n \frac{E_t^{PPP,Steuer} + R_t^{PPP} + P_t^{PPP,Unter} - I_t^{PPP}}{(1+q)^{(t-t_B)}}$$

$NPV_{t_B}^{PPP,I/II}$ = NPV of the service provision PPP in the 1st resp. 2nd long-term phase

$E_0^{PPP,TrAction}$ = Transaction costs at point in time $t=0$

$E_t^{PPP,Trans}$ = Transition costs (only during the establishment phase)

$E_t^{PPP,Man}$	= Expenditure for managing the service provision PPP
R_t^{PPP}	= Risk costs of the service provision PPP
$P_t^{PPP,Contr}$	= Contractor's prices for the service provision PPP
I_t^{PPP}	= Local authority income from service provision PPP
q	= Discount rate
t_B	= Reference point in time

9. COMPARISONS OF ECONOMIC EFFICIENCY I AND II

The two comparisons of economic efficiency only differ in terms of the evaluation of the PPP form of service provision. The Net Present Values of the two forms of delivery are compared with each other in both cases. The comparison of economic efficiency II further differentiates between two long-term phases.

Changing street maintenance is always expedient if the Net Present Value of the service provision PPP is smaller than the Public Sector Comparator. In the course of analyzing the economic efficiency, this condition must first be met for the comparison of economic efficiency I, and subsequently for both long-term phases of the comparison of economic efficiency II.

10. SYSTEM BOUNDARIES

A meaningful comparison of the economic efficiency between the various forms of performing street maintenance must be based on a clear definition of the system boundaries of the model used. This necessitates the assumption of comparable boundary conditions. As such, both content and time system boundaries must be defined for the analysis. These system boundaries apply both to the calculation of the Public Sector Comparator and to the forecast resp. calculation of the PPP expenditure.

Since the public sector generally uses its own staff and equipment to perform street maintenance prior to any possible PPP performance, extensive problems arise when defining the boundaries of the system in question for analyzing economic efficiency. This applies, above all, to capital investments, such as equipment and real estate, but also to the workforce, some of whom will still be needed, some of whom can be taken on by the private contractor, and some of whom will have to be released after the relevant periods of notice.

10.1 CONTENT BOUNDARIES

The methods to be used in performing the analysis of economic efficiency first need to be defined.

Since the analysis needs to cover long periods, a dynamic method that discounts future cash flows to a reference point in time is a definite must. To this end, the relevant Net Present Value based on discounted expenditure and income over the period is calculated for both forms of delivery.

Ongoing expenditure and income relating to street maintenance are incorporated directly into the calculation of the Net Present Value. In the case of longer-term investments in capital goods, the analysis must be more differentiated (see Figure 4). In the case of street maintenance, such capital goods include, for example, the equipment and real estate needed to perform the maintenance works (machinery, building yard, administrative buildings).

There are two possible fundamental approaches to including the asset values and the addition and disposal of investment goods:

- Calculating the Net Present Value by including the individual cash flows at purchase and sale
- Calculating the Equivalent Annual Costs from the annual depreciation and interest on the invested capital

The costs of maintaining and repairing the capital goods can be included directly in the calculation of the Net Present Value.

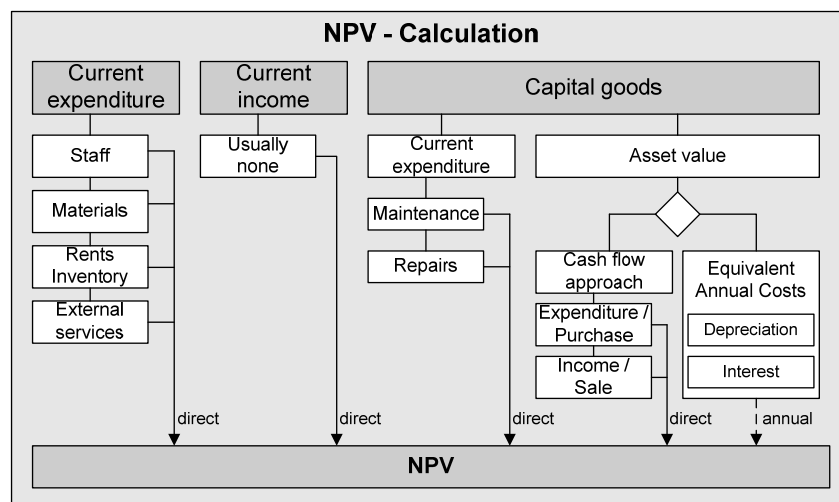


Figure 4 NPV calculation overview

10.1.1 Incorporating capital goods - Cash flow approach:

When calculating the Net Present Value, the income and expenditure relating to the purchase and sale of capital goods over the analyzed period are included directly. Once a piece of equipment has reached the end of its service life, a corresponding replacement investment has to be planned.

$$NPV_{t_B}^{CapitalGoods} = \sum_{i=1}^{m_A} \frac{E_i}{(1+q)^{(t(i)-t_B)}} - \sum_{j=1}^{m_E} \frac{I_j}{(1+q)^{(t(j)-t_B)}} \quad (4)$$

$NPV_{t_B}^{CapitalGoods}$ = NPV including capital goods

m_A = Number of purchases over the analyzed period

m_E = Number of sales over the analyzed period

E_i = Expenditure i

I_j = Income j

$t(i)/t(j)$ = Point in time at which expenditure i is incurred or income j is generated

q = Discount factor

10.1.2 Incorporating capital goods - Equivalent Annual Costs:

In this case, the average annual costs incurred by the investment are included. These include annual depreciation and interest on the invested capital.

$$NPV_{t_B}^{CapitalGoods} = \sum_{t=1}^n \frac{D_t + A_t \cdot q}{(1+q)^{(t-t_B)}} \quad (5)$$

n = Last year of the analyzed period

D_t = Total depreciation in year t

A_t = Average asset value in year t

With this approach, investments and disposals only indirectly impact the annual costs through interest payments on invested capital and changed rates of depreciation. Income and expenditure are not included directly.

10.2 TIME BOUNDARIES

A uniform timeframe must be defined for both forms of delivery for purposes of comparison. The contract term of a possible PPP agreement is used for this, thus defining a start point $t=0$ and end point $t=n$. In order to ensure the comparability of the two forms of delivery, comparable conditions must prevail at the start and end points in time of both forms of delivery.

In this case, again, a closer analysis is needed, especially of the capital goods, i.e. equipment and real estate.

10.2.1 Incorporating capital goods - Cash flow approach:

This alternative adds the income from the sale of real estate and inventory straight to the Net Present Value. As such, the unilateral sale of capital goods can distort the result of the analysis of economic efficiency of a service provision PPP. Two approaches to defining system boundaries, which both ensure clear time boundaries on the existing assets, are outlined below.

NPV system variant A:

In the case of NPV system variant A (see Figure 5), all already existing assets are available to both forms of delivery at the beginning of the analyzed period, thus ensuring the same parameters for both forms of delivery at this point in time. But real estate or inventory assets can be sold in whole or in part at the start or during the course of PPP performance. As such, in the case of PS delivery, the residual value of these assets must be included as income at the end of the analyzed period. This is crucial in order to reinstate the same parameters at point in time $t=n$ for both sides, irrespective of whether the assets have actually been sold or not.

NPV system variant A1 assumes that assets which are no longer needed for the PPP form of delivery are sold at the start of the term. System variant A2 applies when these assets are sold either at the end of or during the term, if they cannot be sold in the short term, for example. In this case, rental income from a possible lease of the assets to third parties is generated up to the time of sale in the case of PPP performance.

NPV system variant B:

In the case of NPV system variant B (see Figure 5), the comparability of the parameters is produced by setting the assets to zero at the start and end of the term for both forms of delivery. As such, the assets are theoretically sold at a point in time $t < 0$. The income from this sale is not included, since it does not occur during the analyzed period. In the case of PS performance, the assets that are still needed must either be repurchased at the start of the analyzed period (B1), in which case the associated expenditure is included in the calculation of the Net Present Value, or the cost of these assets is included as rental expenditure (B2). In the case of NPV system variant B1, the residual value of the assets is included as income from a theoretical sale at the end of the term.

Both B1 and B2 demonstrate theoretical system boundaries. Sales do not actually take place and, as such, real estate and inventory is not actually leased, unless this was already the case.

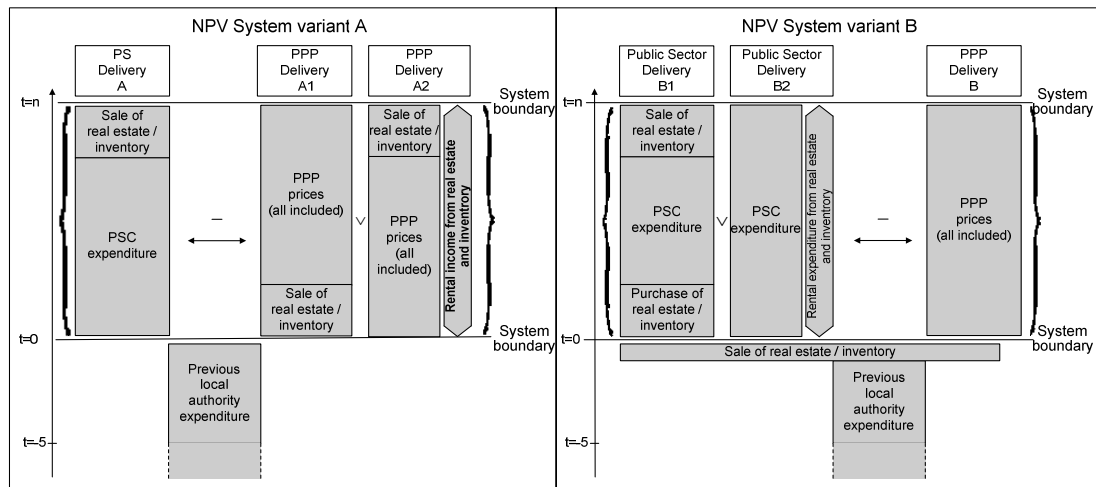


Figure 5 NPV system variants for cash flow oriented analysis of capital goods

10.2.2 Incorporating capital goods - Equivalent Annual Costs:

The comparability of the existing assets at the start and end of the analyzed period are irrelevant in the case of Equivalent Annual Costs. By analyzing the annual depreciation, the relevant loss of value is included directly and further delimitation is therefore no longer necessary at the end of the term. Although in the case of a service provision PPP the sale of real estate and inventory represents cash flow, it is not included directly in the Equivalent Annual Costs.

As such it is easier to define the system boundaries of the model for comparing economic efficiency than is the case at cash flow level. The costs for both forms of delivery are included as depreciation and interest on invested capital over the analyzed period. The calculation of imputed interest on the assets does, however, necessitate an analysis at asset level, in addition to the cost level.

10.2.3 Evaluating the models for comparing economic efficiency

Both methods can be sensibly applied to analyzing two alternative approaches to performing the works in question. The decision as to which method is chosen depends primarily on the structure of the data collected in the past with regard to street maintenance costs resp. expenditure. The figures relating to the asset values of the equipment and real estate are particularly important.

Cash flow oriented analysis is always expedient if the local authority's accounting systems only cover expenditure and income, but not depreciation or developments in asset values. The determination of the Equivalent Annual Costs using the method proposed here pre-necessitates that these figures are actually known. By the same token, unlike the direct inclusion of cash flows, there is no need to know the points in time at which the assets were purchased and sold and the then valid prices. Knowing the

annual depreciation in the value of the individual assets and the value of the assets is sufficient.

Given that it is easier to apply, especially when planning future expenditure, the Equivalent Annual Cost method is the better alternative for most local authorities. The cash flow approach using system variant B2 is quasi equivalent to the Equivalent Annual Cost method. It offers a means of easily and practically mapping the actual payment streams, which are hard to capture, in the form of rents. These rents can be derived, e.g., from standard market rental rates.

The results of the cash flow approach and the Equivalent Annual Cost approach turn out to be identical (Lücke, 1955). This parity of results means that a cash flow analysis of the capital goods for one form of delivery (PS or PPP) could conceivably be compared with the Equivalent Annual Costs of the capital goods for another form of delivery. In this case is to be considered that only NPV system variant B is congruent to the Equivalent Annual Cost method since, in this case, a self-contained system comprised of the purchase and sale of assets exists for both forms of delivery. Variant A only includes sales, but not purchases of assets, and therefore only offers a self-contained system for comparisons within this variant.

11. CONCLUSION

The model for analyzing economic efficiency presented in this paper offers the decision makers in local authorities a scientifically based and practically applicable tool for evaluating the economic efficiency of alternative approaches to performing maintenance works. The model was developed for the maintenance of communal street networks but can be marginally adapted for application to the maintenance of other structures.

The calculations can be performed using probabilistically distributed input variables to underline the results. This integrates uncertainties relating to the prediction of costs into the calculation, thus providing information about the possible scatter ranges of the results. Both this and a comprehensive risk analysis of the analyzed systems are the focus of research projects that are currently ongoing at the Institute for Construction Engineering and Management at ETH Zurich.

The overall outcome will be the creation of a complete concept for planning and implementing Public Private Partnerships for maintenance works.

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