

Trade-offs in Infrastructure Investment Decisions: between Financial and Public Interests

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Abstract

The economic crisis of 2007 has limited financial resources of governments for public works and service. For this reason, asset managers of transport infrastructure need to make priorities on their investments. This requires the identification of clear trade-offs between financial and public interests. However, academics have argued that the safeguarding of public interests for infrastructure is in jeopardy, because of ambiguity in the identification of these trade-offs. This paper explores the relation between financial and public interests. Subsequently it develops a conceptual framework to better understand how these interests can be combined in terms of infrastructure investment decisions for asset managers.

Keywords: infrastructure, asset management, public value, investment decision support

1. Introduction

Managers of transport infrastructure experience increased pressure these days. Many infrastructure assets in developed countries enter a stage of deterioration and require substantial investment in maintenance, renovation and rehabilitation (Klatter and van Noortwijk, 2003). In addition, the usage of transport modes surges both in personal use and goods haulage (DG TREN, 2009). These trends come at an unpleasant moment, since many governments have faced budgetary constraints for years and have cut back in financial resources for public works and service (European Commission, 2009). Not surprisingly, governmental bodies expect more private sector involvement in the long term. Public Private Partnerships have been already widely used to deliver critical infrastructure such as the use of DBFM (Design Build Finance Maintenance) contracts in the Netherlands.

Many private companies prepare themselves to adopt the finance and maintenance tasks for infrastructure. This seems a good solution to the public funding gap. However, private companies are known to have predominantly commercial interests rather than public ones. Therefore, public agencies remain primarily responsible for the public interests, such as safety and accessibility. A major challenge for infrastructure managers is to find the right balance between financial and public interests while deciding on the interventions that are required to ensure the desired performance.

This paper explores the relationship between financial and public interests in infrastructure investment decisions. It aims at developing a framework of trade-offs in infrastructure decision making. In the next section public and financial interests in infrastructure are outlined. That is followed by a description of the decisions infrastructure managers make. Then the framework is presented and explains and financial interests lead to trade-offs in the infrastructure decision making.

An application for the asset managers is proposed to use in their decision making process. In the intended way public organizations can safeguard the public interests in the investment decision process, while private funding is the leading determinant in the considerations. The last section concludes the paper with the limitations of this study and recommendations for further research.

2. Public and financial interests in infrastructure

2.1 Public interests

Established transport infrastructure is a key enabler of a nations' economic development (Sělih et al. 2008). For example, it connects citizens and businesses for their basic transportation needs. The collective needs associated with this infrastructure are protected by governmental organizations. This paper defines public interests in transportation infrastructure as stakes that can render benefits to a collective group once safeguarded by public asset managers. The debate around safeguarding public interests has been given shape by Public Value Theory. It introduces the creation of public values as a strategy for governments (Moore, 1995). The theory is further elaborated in the section about decision

making. Below we give an overview of the public interests that can be considered in transport infrastructure.

Due to space limitations, we provide lists of public interests in Table 1. Subsequently, we discuss the main aspects of public interests and the relation with infrastructure. Several sources in the public administration and public management literature provide inventories. They can be either categorized as *public interests* (e.g. Blumstein, 1999), *services of general interest* (European Commission, 2009) or *public values* (e.g. Moore, 1995, Beck Jørgensen and Bozeman, 2007).

Table 1 – Public Interests for Infrastructure

| <i>Beck Jørgensen and Bozeman 2007</i> | <i>Meynhardt 2009</i> | <i>Koppenjan et al. 2008</i> | <i>Arts, Dicke and Hancher 2008</i> | <i>De Bruijn and Dicke 2006</i> |
|---|------------------------------|--------------------------------------|--|--|
| <i>Common Good</i> | <i>Human dignity</i> | <i>Quality of Service</i> | <i>Freedom of Choice</i> | <i>Integrity</i> |
| <i>Altruism</i> | <i>Diversity</i> | <i>Universal Access</i> | <i>Affordability</i> | <i>Openness</i> |
| <i>Sustainability</i> | <i>Integrity</i> | <i>Equity</i> | <i>Accessibility</i> | <i>Accountability</i> |
| <i>Regime Dignity</i> | <i>Secrecy</i> | <i>Low price</i> | <i>Reliability</i> | |
| <i>Majority Rule</i> | <i>Cultural Heritage</i> | <i>Certainty of service delivery</i> | <i>Safety</i> | |
| <i>User Democracy</i> | <i>Beauty of Spaces</i> | <i>Customer protection</i> | <i>Sustainability</i> | |
| <i>Protection of Minorities</i> | <i>Reliability</i> | | <i>Maintainability of position of Businesses in the nation</i> | |
| <i>Political Loyalties</i> | <i>Service Quality</i> | | <i>Improvement of position of Businesses in the nation</i> | |
| <i>Openness-secrecy</i> | <i>Citizen Involvement</i> | | | |
| <i>Advocacy and Neutrality</i> | <i>Equal opportunities</i> | | | |
| <i>Competitiveness-Cooperativeness</i> | <i>Compromise</i> | | | |
| <i>Robustness</i> | <i>Social Innovation</i> | | | |
| <i>Innovation</i> | <i>Self initiative</i> | | | |
| <i>Productivity</i> | <i>Openness</i> | | | |
| <i>Selfdevelopment of Employees</i> | <i>Robustness</i> | | | |
| <i>Accountability</i> | <i>Sustainability</i> | | | |
| <i>Legality</i> | | | | |
| <i>Equity</i> | | | | |
| <i>Dialogue</i> | | | | |
| <i>User Orientation</i> | | | | |

Two lists are directly related to infrastructure. Koppenjan et al. (2008) provides a list of public values related to public infrastructure, especially privatized. Arts, Dicke and Hancher (2008) provide a list of public interests on infrastructure in particular to mobility in the Netherlands. They note that this list is limited and inaccurate since authorities are not able to make these interests explicit. Most of these public interests are useful for infrastructure in relation to the user, in general and economic¹.

Beck Jørgensen and Bozeman (2007) delivers a list of value categories where public values are related in a structured universe². These are more focused on the society in a broad context. A few public interests are clearly related to infrastructure. For example, public infrastructure is a *common good* for all citizens. Moreover, *sustainability* refers to the existing infrastructure with a long life-cycle.

Meynhardt (2009) provides a list of 16 generic values that are grouped in four categories: moral-ethical, hedonistic-esthetical, political-social and utilitarian-instrumental. Please consult Meynhardt (2009, pp. 208) for the full explanation of these categories.

De Bruijn and Dicke (2006) provide a list of process related public values on the behavior that public organizations should have. These types of public interests are focused on the operations of a public organization and its' communication with the public.

In sum, public interests of five sources have been presented in Table 1. The ways in which these lists have been identified and structured varies remarkably. The relation between each of these public interests and infrastructure decisions is discussed in a later section of the paper.

2.2 Financial interest

In general, the financial interest for infrastructure is the same as other assets. The less financial resources spent by the investor to achieve its' objective the better. It is also referred to as the concept of Value for Money (Grimsey and Lewis, 2005). Some specific elements exist behind this notion. These are explained in this section.

Rouse and Chiu (2009) make the value for money explicit by saying that investments need to be efficient, economical and effective. Efficiency is related to the costs that asset managers have relative to the frequency and timing that the intervention activities, e.g. maintenance, take place. Ozbek (2007) considers efficiency as an important financial interest for infrastructure management, specifically roads. Economical refers to the level of costs that the asset managers make for a certain infrastructure quality level. Finally, effectiveness refers to the relation between infrastructure quality and the frequency and timing that interventions take.

¹ For the structure of their public value universe, please consult Beck Jørgensen and Bozeman (2008, pp. 359 – 361).

² The lists of Meynhardt (2009), Beck Jørgensen and Bozeman (2008) and Arts, Dicke and Hancher (2008) have a predefined structure through which they categorize public interests. We are only interested in the lower level public interests that are provided in these sources.

Another important aspect of financial interests is the costs of the asset over its' life-cycle (Schuman and Brent, 2005). The longer an asset can perform its' intended function, the longer an asset manager can postpone re-investments. By analyzing the costs over the life-cycle, like a NPV (Net Present Value) analysis, efforts can be done to minimize the costs involved per year to have the asset in service.

Tam and Price (2008) give four important financial interests for asset managers: budget dimension, time dimension, risk dimension and return on investment. The budget dimension refers to the maximum financial resources available for an asset manager to allocate in a certain time. The time dimension refers to the time that the asset is out of operation. In infrastructure this can be the closure of a road for maintenance. The risk dimension involves the impact that a certain malfunctioning of the asset has and its' likelihood of occurrence. For example, cracks in a road or sign distortions on railways. Last but not least, the return on investment is an important financial interest. On the one hand public organizations suffice with nil return, because they are non-for-profit organizations (Micheli and Kennerley, 2005). On the other hand private organizations most likely set their required return on investment above 0%. They approach financial interests with a commercial perspective.

In sum, the following financial interests have been identified: effectiveness, efficiency, economics, costs incurred over the asset life cycle, budget constraints, time constraints and risks. These are either referred to as limitations to the use of financial resources or key factors to leverage.

3. Decisions in infrastructure management

Lately, transport infrastructure, such as roads and rails, in the European Union experiences many influences from its environment. These include the deterioration of infrastructure objects (Klatter and van Noortwijk, 2003), financial turmoil and the increasing congestion problem (DG TREN, 2009). Therefore, many scholars and practitioners are turning their attention to the asset manager. They claim that the role of the asset manager needs more emphasis to improve maintenance and construction interventions on existing infrastructure. By definition, this is done by balancing performance, risk and expenditures over the life cycle of the assets (PAS-55, 2008). According to Moon et al. (2009) Asset Management aids in the appropriate allocation of funds by properly identifying trade-offs (Moon et al. 2009). They go on by saying that it does not increase funding (Moon et al. 2009). Therefore, decisions regarding infrastructure or asset management are typically related to identifying the requirements of the infrastructure and their realization. In the academic literature regarding asset management decisions, three main categories can be found. These include decisions regarding objective(s), asset performance and intervention(s) for infrastructure. The overview provided here is not exhaustive.

3.1 Decisions with regard to the objective(s)

Transport infrastructure is maintained and built to achieve certain objectives, such as safety and accessibility (Koppenjan et al. 2008). These objectives cannot be realized if there is no financing

available. For this reason an asset manager needs to identify the objectives that require funding. It also needs to consider the source of finance.

The objectives are often related to the achievement of a project, program or the organization. This makes the scope, scale and timing important aspects for decisions regarding the certain objectives. For example, in the Netherlands a program was deployed to reconstruct over 1000 bridges and tunnels simultaneously in 2005. Also, individual projects can be decided as outlier occasions. Like the initiation of a complete re-pavement of a road due to critical deterioration.

The objectives are stated as the fulfillment of certain improvement needs or achievement of expectations. This concerns decisions with regard determination of the public interests. Moreover, the functional requirements need to be derived based on these public interests. A decision also needs to be made on the desired level of detail in the objective(s). In sum, decisions with regard to objective(s) on infrastructure are outlined in Table 2.

3.2 Decisions with regard to the infrastructure asset performance

There is a difference between the planned objective and the realized objective for an asset. Performance measurement is used to close the gap between the planned and realized objectives Vanier (2001). Otto and Ariaratnam (1999) explain this role of performance measurement. Input, process, output and outcome measures are employed to capture the planning and realization of the performance (Otto and Ariaratnam, 1999, pp. 47). Inputs such as resources are measured to capture the enabling factors of achieving the objectives. Process measures are taken from within the operation, e.g. the intervention of the organization. Output measures refer to the performance that is directly achieved by action or intervention. Finally the outcome measure is captured by observing changes after the output has been achieved³.

When an investment is made, the criteria and their desirable level are clarified through functional requirements. Decisions with regard to asset performance are related with the translation, measurement and monitoring of functional requirements elicited in technical requirements. The translation can be done through different methods, such as QFD (Quality Functional Deployment). The measurement and monitoring of asset performance can be done through different ways, such as visual inspections or more objective measurements in certain periodic intervals. The decisions related to asset performance of infrastructure are provided in Table 2.

³ Please consult Otto and Ariaratnam (1999, pp. 47) for examples of these four types of measures.

3.3 Decisions with regard to infrastructure interventions

The intervention is the choice for a type of action on the road and a need for improvement. For example, an asset manager decides to maintain a road correctively or reconstruct it completely (Worm and van Harten, 1996). In practice, the list of decisions taken with regard to infrastructure interventions is quite extensive. The main decisions regarding the infrastructure interventions include: the identification of failures; choice of technical improvements; type of intervention; determination of failure locations; the identification and bundling of activities and the planning of the intervention. This list is given in Table 2.

4. The conceptual framework of balancing public and financial interests in infrastructure investment decisions

The conceptual framework is given in Figure 1. Asset Management is the centre of the conceptual framework. The main Asset Management decision categories are displayed by diamond shaped forms: objectives, asset performance and interventions. These decisions impact one another. Therefore mutual relations have been indicated in the framework. This is based on the literature on the following themes: *integral performance measurement* (e.g. Rouse and Putterill, 2003), *multiple objectives and investment decisions* (e.g. Pascual, 2009) and *the selection of intervention options* (e.g. Rouse and Chiu, 2009). The mutual influences are visible over time. Van Gestel et al. (2008) underline this with empirical evidence from 6 infrastructure projects in the Netherlands.

Table 2 – Decisions in Infrastructure Management

| <i>Objectives</i> | <i>Asset Performance</i> | <i>Interventions</i> |
|---|---|--|
| <i>Objectives</i> | <i>Performance criteria</i> | <i>Failure Identification</i> |
| <i>Period of Consideration</i> | <i>Input Measures</i> | <i>Choice of Technical Improvements</i> |
| <i>Type of Assets</i> | <i>Process Measures</i> | <i>Type of Intervention</i> |
| <i>Scale</i> | <i>Output Measures</i> | <i>Determination of Failure Location</i> |
| <i>Timing of Achievement</i> | <i>Outcome Measures</i> | <i>Identification of Activities</i> |
| <i>Source of Finance</i> | <i>Translation of Functional Requirements</i> | <i>Bundling of Activities</i> |
| <i>Public Interests</i> | <i>Measurement of Requirements</i> | <i>Planning of the Intervention</i> |
| <i>Functional Requirements</i> | <i>Monitoring of Requirements</i> | |
| <i>Financial Interests and Requirements</i> | | |
| <i>Level of Detail</i> | | |

4.1 Trade-offs in asset management

Moon et al. (2009) say that in order to make decisions, an explicit identification of trade-offs is essential in asset management. A trade-off is “*a balance achieved between two desirable but incompatible features, i.e. a compromise*” (Oxford Dictionary, 2006, pp. 1528). Trade-offs in Asset Management can be related to the objectives, asset performance and interventions by looking at the functional, financial and technical requirements as inputs to these decisions (Figure 1). This results in three trade-off types.

First, the *identification of public interests* is a challenge to make the objectives more explicit. Meynhardt (2009) argues that public values are hard to define or objectify. On the one hand public interests can conflict between different stakeholders (Koppenjan et al. 2008). On the other hand, the link between financial and non-financial data is powerful to indicate the performance of infrastructure (Garvin, 2008) but the indication is underdeveloped.

Second, the translation between functional and technical requirements is a challenge. The trade-off refers to the appropriateness of a set of performance criteria to reflect the objective (Behn, 2003). This process makes the asset performance for the planned objectives explicit. The clarification of these technical requirements is necessary to achieve conformity with interventions, such as maintenance and rehabilitation. However, to achieve this is problematic for public organizations, due to the multi objectives and influences of the output (de Bruijn, 2007).

Final, the design of the appropriate intervention is a challenge. An appropriate intervention is achieved when the objectives and required asset performance are balanced between the technical requirements and financial requirements (Vanier, 2001). The increasing emphasis on the asset life-cycle enlarges the range of the intervention options in this trade-off (Amadi-Echendu, 2004), ranging from corrective maintenance to new construction. The boundaries between these types of interventions are complicated to determine (Link, 1999).

4.2 Asset, equity and liability role

Three roles exist in the environment that affect the outcome of the trade-offs in asset management. These include the *Asset, Equity and Liability* roles. These labels are chosen for their appearance on the balance sheet of any organization (Ross et al. 2002).

The *Asset Role* represents the interested party or parties that use(s) or is influenced by the asset in its physical form. It is supposedly this roles' influence to make the public interests in the asset known by delivering functional requirements to the objective and asset performance. An example is the Ministry of Transport elaborating hard values such as policies and legislation (Koppenjan et al. 2008). However, with the increasing congestion and deteriorated infrastructure objects, the community involvement can safeguard the public interest in the decision making process of the asset manager. In the USA, Portland Transportation saved 8 million by involving the public in the asset renewal

decisions (Bugas-Schramm, 2008). This paper argues that this role should take lead in the identification process of the public interests for infrastructure investment decisions.

The *Equity Role* represents the party or parties that invest(s) into the asset for an expected return. The investment can only have a maximized return on investment or value for money when the planned objective is realized and the involved financial risks on the intervention are minimized Vanier (2001). This paper argues that this role should take the lead in the identification of financial interests for infrastructure investment decisions.

The *Liability Role* represents the party or parties that are obligated to deliver the objective physically for payment. An example of this role is a consortium of more than one construction companies performing the maintenance tasks or construction. This role is important for the realization of the objectives to the asset. However, any further elaboration on this role is out of the scope of this paper.

In sum, this conceptual framework gives an outline of the domain in which trade-offs for infrastructure investment decisions are made. The balancing between public and financial interests is indicated to be amongst the Asset and the Equity role. However, sources from the year 2006 to 2009 indicate that the proper identification of these trade-offs are still underdeveloped for infrastructure investment decision making. In the next section, we propose an application by combining the public and financial interests.

5. Proposed application for the framework

This section proposes a method to combine the public and financial interests. Two theories provide a rational for a potential application: Public Value Theory (Moore, 1995) and Real Options Theory (Myers, 1977). We discuss their relevance and application with this framework briefly, due to limitations of space. The further elaboration of this application is part of a PhD project.

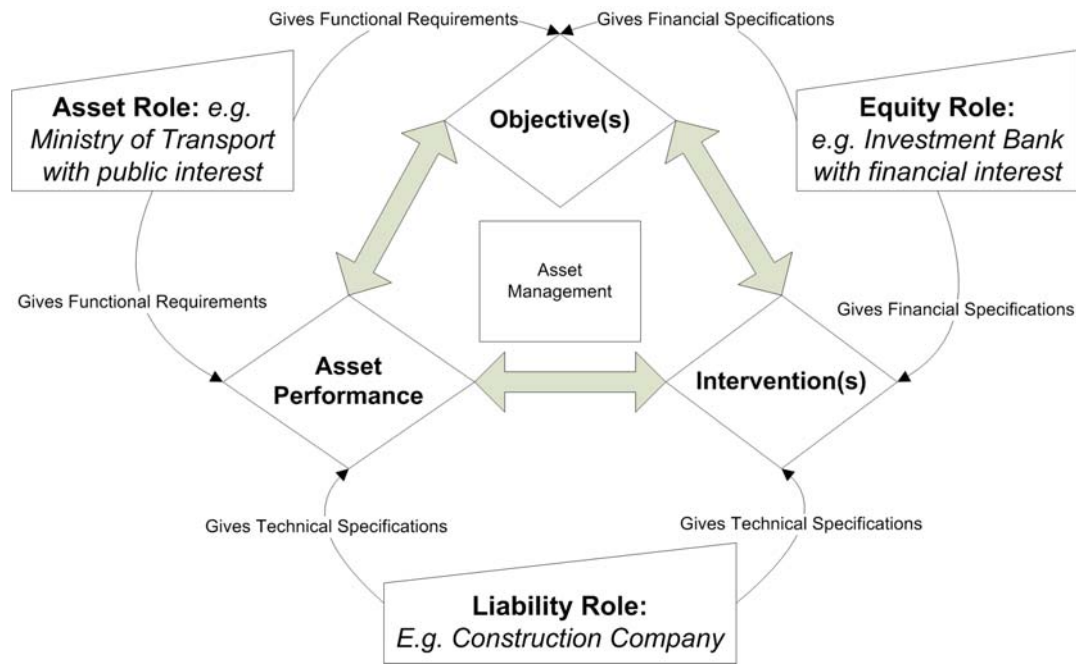


Figure 1 – Conceptual Framework

5.1 Public values theory

Public Value introduces the creation of public values as a strategy for governments. Although several scholars (e.g. Jørgensen and Bozeman, 2007; Koppenjan et al. 2008) develop lists of public values, Meynhardt (2009) argues that the identification of public values cannot be reduced to for the purpose of static models, such as single cost-benefit analyses, customer orientation and rational decision making models. *“The term public value attracts projections concerning the need of engage in a dialogue about values, value conflict and the role of the public sector in changing societal contexts”* (Meynhardt, 2009, pp. 192). Furthermore Stoker (2006) explains that asset managers are focusing beyond the conformity of procedures and targets. *“They are asking if their actions are bringing a net benefit to society”* (Stoker, 2006, pp. 49). As an example, Hennessy and Platt (2006) report on an infrastructure project where a debate is fed by community involvement.

Meynhardt (2009) proposes 1) to relate values systematically to each other and 2) to structure them according to a logic for the basis of evaluation. This can be done by involving the community in way as Meynhardt (2009, pp. 211) suggests *“if the value is not in peoples’ mind, it is not “real””*. Moreover, the objective of the infrastructure can act as a logic for the development of public performance measurements (Behn, 2003).

5.2 Real options theory

Real Options is termed as the opportunity to acquire real assets in the future at potentially favorable prices. Therefore the price calculation for a real option is treated in an identical way to call options on the stock exchange. A call option is the right to buy a fixed number of shares of stock at a predefined

price within a specified time (Ross et al. 2002). This can be applied to physical assets by means of identifying interventions and their financial requirements over time (Miller and Waller, 2003).

The theory accounts for uncertainty in investment price prediction over time. Typically, this is often done by means of event tree analysis in the pricing process (Anderson, 2000). Real options theory encompasses developing alternative values (financial) at discrete points in time over the life cycle of an asset. An example is the NPV analysis (Ross et al. 2002). This way it projects future cash flows and helps to choose an appropriate discount rate, e.g. for identifying the lowest acceptable return on investment.

Triantis and Borison (2001) suggest an interesting application of real options that can be beneficial for infrastructure investment decisions. They propose that real options analysis should be part of the strategic planning and capital budgeting process. Miller and Waller (2003) propose that the asset managers could use scenario planning to formalize the real options analysis and make the financial interest more explicit.

6. Conclusions

This paper addresses the investment decision making of asset managers responsible for transport infrastructure. It identifies public interests and financial interests related to infrastructure. Moreover, it provides a list of infrastructure management decisions by the categories objective, performance and intervention.

The conceptual framework outlines the domain in which trade-offs for infrastructure investment decisions are made. The asset role and equity role should take the lead in the identification of public and financial interests. The infrastructure objective decision can act as a logic for this identification. The suggestion of Garvin (2008) to link financial pairwise with non-financial data can combine the public and financial interests.

Public interests can be made more explicit in terms of a systematic way of relating interests. For example, this can be done by means of community involvement (e.g. Hennessy and Platt, 2006).

Financial interests can be made more explicit over the life cycle of the asset by means of more formal analysis in the form of scenario analysis. In other words, asset managers can identify possible interventions for the asset that satisfy the objective and calculate the life cycle costs using real option analysis (Miller and Waller, 2003).

It is recommended that the link pair-wise link that Garvin (2008) concludes is further elaborated. Moreover, the suggestions made in this paper to use Public Value Theory and Real Options Theory can advance by 1) elaborating further on the methodological steps and 2) perform empirical analysis.

The limitations to the research are summarized as follows. First, the list of public interests and financial interests are not exhaustive and disputable. Public interests are for example ambiguous and

stakeholder dependent. Financial interests are dependent on the public or private party that funds the infrastructure. Second, the list of decisions in table 2 is also not exhaustive. Finally, the amount of sources available on this topic is bigger than the sources referred to in this paper. For that reason, these lists cannot be completely representative of all the decisions and interests available in the literature.

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