# Cost drivers in public construction projects from a value-creation perspective

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## Abstract

Balancing value and costs is a key decision in construction projects. This paper draws on case study research of public school projects to identify cost drivers and relations between them. Costs are largely decided before or in the planning phase due to owner's decisions. Investments are made to provide new capabilities or reduce operating costs, such as energy consumption and maintenance. During execution, project management seeks to reduce and cope with costs through increased collaboration. User involvement is important. The paper puts the cost side of value creation on the agenda and empirically shows how different costs are interrelated.

**Keywords:** Construction projects, value, costs, public sector, project management

**Introduction**

Delivering value is the end goal of any construction project (Emmitt et al., 2005), and value creation takes place on several levels in a construction supply chain. The value creation that justifies the investment cost is made when the building is in use. Value is the difference between what you get and what you give, i.e. cost and benefit (Kelly et al., 2004). Thus, value increases either by reducing costs or increasing benefits. Although this could be expressed mathematically as value = benefit/cost, this equation is too simplistic (Rooke et al., 2010; Thyssen et al., 2010). In this paper, we comply with the notion that value is the result of an *evaluative* judgment, where both 'get' and 'give' components are always considered (Drevland and Lohne, 2015), and where different stakeholders are likely to have differing perceptions of value (Knotten et al., 2016).

This paper focuses on the cost side of value. Cost control and cost drivers are key issues in major investment projects. The purpose of the research is to identify key drivers that decide costs in investment and in operation. The objective is both to clarify drivers of investment costs, as well as mapping the consequences for operation and maintenance costs. Literature with relevance to cost drivers comes from different research traditions, including scope management, value engineering, planning, project uncertainty and other topics related to construction and project management. Finally, the paper discusses examples of project management approaches in relation to identifying cost drivers. Understanding the key drivers and how they relate to each other might explain why some drivers seem to create knock-on effects and generate more costs added than each of them individually. Such knowledge can support choices that optimize value.

To obtain the purpose and objectives, the paper reports on preliminary findings and analyses from an embedded case study of a public proprietor of schools in Oslo, Norway, and three of its school construction projects. The next sections present the theoretical basis for the study, the research design, and preliminary results of the study and conclusions.

**Theoretical basis**

The concept of value exists in different fields (Khalifa, 2004). This paper is concerned about 'value' within the domain of construction projects. According to Emmit et al. (2005), value is the end goal of any construction project. The most common definition of value in this context is that value is the relationship between what you give and what you get, or between cost and benefit (Kelly et al., 2004). Value is, however, the result of an *evaluative* judgment, where both 'get' and 'give' components are always considered (Drevland and Lohne, 2015). Optimizing value delivery requires a conscious notion of the relationship between what something costs and the benefit it yields.

The literature has paid much attention to the assessment of different value components, especially concerning the 'give' side of value. Although cost estimation of the investment cost of capital projects can hardly be considered trivial, it is definitely a mature field. Cost estimation is the iterative process of developing an approximation of the monetary resources needed to complete project activities. Project teams should estimate costs for all resources that will be charged to the project (PMI 2013). Major tools and techniques in project cost estimation include, expert judgment, analogous estimating, parametric estimating, bottom-up estimating, three-point estimates, reserve analysis, and vendor bid analysis. Each of these have their own guidelines and best practices. PMI also emphasizes that cost estimation is dependent on all other project management skills (scope, time, quality, risk management etc.). This indicates that cost estimation is a complex process that includes a multitude of tasks. The cost side of projects can be developed according to several "clean" strategies: minimizing investment cost, design to cost (maximizing the value to a given cost) (Pennanen et al., 2011) or maximizing value and accepting the resulting cost. In real life, the limitation in available financing will normally lead to the task of optimizing the relationship between value and cost. Best practice in this optimization task includes Life cycle costing (Kirk and Dell'Isola 1995, Woodward 1997), sustainability (Life cycle analysis; Norman et al. 2006) and Net Present Value (Copeland et al. (2005). However, experience tells us most construction projects struggle getting beyond the basic cost – benefit trade-off.

The 'get' side of value is typically less quantified than the 'give' side. However, approaches for assessing it can be found in the contexts of Building Performance Evaluation (BPE) and Post Occupancy Evaluation (POE), which are concerned with the usability of facilities (Mallory-Hill et al., 2012). For example, Life Cycle Cost Analysis (LCCA) goes beyond only considering the investment cost of a facility to also considering the total cost of owning, operating and maintaining a facility through its life cycle (Cabeza et al., 2014). With regard to balancing different aspects of value, there are several methodological frameworks tied to this. The most notable being Value Management

(VM) and Value Engineering (VE). VE includes critical review of proposed deliveries and specifications of a project to determine the most resource-efficient approaches to achieve the core functionality of the delivery (Dell'isola, 1966, Green 1991, Younker 2003, Jay and Bowen 2015). VM can be seen as a later development of VE (Stichler, 2009). While VE is purely cost focused, the focus of VM is fulfilment of the business project.

Besides specific methodological approaches, little work seems to have been done concerning how the different 'get' and 'give' components of value are balanced in construction projects, particularly related to decision processes. Considerable attention has been paid to best practices for developing the best project concepts and solutions. The psychology behind investment decisions and methods for systematic analysis, and theory for underpinning of rational choices have been developed. Examples include the studies conducted by Tversky and Kahneman (1974), Keeney (1988, 1996), Goodwin and Wright (1998). However, the problems of making the right decisions still occur. The awareness of the importance of early decisions has reached the project management area, resulting in an important correction to direction, and shifting more focus towards the front-end (Samset 2003). Early decisions and analysis in the period from when an idea emerges until the decision to execute a project is made has the greatest potential for improved value or benefit of investments (Klakegg 2010).

Further, the execution process through all stages of development from the problem or need for a new asset is identified until the result of the project – the building or infrastructure – enters the use and operation phase is also vital to the resulting cost. Not only the application of cost estimation methods, but even more the way different competences are utilized in this process. How and when parties are involved in the planning process and how they collaborate through the process also influence cost for investment and operation of the resulting asset. Appropriate stakeholder involvement is important to create value in projects, since different stakeholders are likely to have different perceptions and thus judgement of value (Knotten et al., 2016). By displaying key stakeholders and together aligning their aims, can help overcome some of the differences (Yang et al., 2009). Keeping the most important stakeholders in mind, it is important to look at the three major groups of stakeholders and their views. Samset (2010) refers to these as perspectives and lists them as the owner perspective, the user perspective and the executing perspective.

In sum, the literature shows that even if much attention has been paid to the 'give' and 'get' sides of construction projects, and several tools, techniques, and methodologies are available for assessing both sides, less is known about the balancing between costs and value, and the decision processes related to these efforts. Decisions, in turn are likely to be influenced by different stakeholders' perceptions and involvement. These insights form the basis for the following research questions addressed in this paper:

- What are key decisions and drivers influencing investment and operating costs in construction projects?
- How do different cost drivers relate to each other and how do they influence value, in terms of use of the buildings?

**Research design and methods**

The paper draws on preliminary findings from an embedded case study of a public proprietor of public schools in Oslo, Norway and three of its recently conducted projects (see Table 1 for an overview). The agency is a client organization on behalf of Oslo municipality. The case study was based on data collected from document analysis and group interviews with key personnel from the client. The group interviews were conducted in a workshop-like manner. One interview was conducted for each of the three projects, and included the responsible project manager and the project director. In addition, a joint interview with people from the project, property and operations departments was conducted. Key questions during the interviews regarding the projects included: what key decisions made during each project phase and other drivers were likely to have influenced upon different types of costs, including investment, project delivery and operating/life cycle costs for the building? The interviewees identified the different cost drivers, connections between them, where they originated in the project process, and the effects that they had on investment and operation costs.

*Table 1- Overview of the projects*

| Type of project | Specific requirements | Type of contract | Finished | Size and investment cost |
|---|---|---|---|---|
| New primary and secondary school for 800 pupils, including an indoor sports arena. | Passive house standard and part of Future built | Design & build | 2014 | 10 100 $m^2$ and 365000 NOK/$m^2$ |
| New primary school for 630 pupils. | Passive house | Design & build, including partnering | 2014 | 7480 $m^2$ and 35 000 NOK/$m^2$ |
| New primary and secondary school for 800 pupils, including indoor sports arena. | Passive house | Design & build | 2015 | 12522$m^2$ and 33700 NOK/$m^2$ |

To aid the interviews and analyses, a recently developed phase model for the Norwegian AEC industry, called "Next step" was used (for an overview of the work, see Klakegg et al., 2015). It is based on a similar set-up as the RIBA Plan of Work (RIBA 2013). The intention is that the construction industry can use the framework as a common reference and to give the industry a common language and collective reference to execute projects. It defines common steps (phases), decision points between steps and important information to be delivered between the actors in the project for each step. The main decisions identify the purpose of every step in the model. Using this model as a common platform for construction projects, is likely to reduce misunderstandings, improve collaboration and give better timing for every stakeholders' contribution in the development process. In addition to the perspectives identified by Samset (2010), a third perspective called supplier perspective and a fourth perspective, called the public perspective are added.  Figure 1 presents an outline of the framework (www.bygg21.no)

| Step | 1 Strategic definition | 2 Brief development | 3 Concept development | 4 Detailed designing | 5 Production | 6 Handover | 7 In use | 8 Termination |
|---|---|---|---|---|---|---|---|---|
| Core process | **Owner** perspective | | | | | | | |
| | **User** perspective | | | | | | | |
| | **Supplier** perspective | | | | | | | |
| | **Public** perspective | | | | | | | |

*Figure 1- Outline of the framework called "Neste Steg" (Next step) (Knotten et al. 2016)*

The different steps are indicated on the top of Figure 1. Each step has a clear purpose and together they cover the different phases of a project. There are eight steps in this model, including termination of the asset after use has ended. This is intended to force stakeholders into thinking through the whole life cycle when making decisions. The logic of the steps is based on a systems thinking approach with input, process, and output logic, creating decisions gates after each step. For each step, main tasks are identified (Klakegg et al. 2010).

Using the “Next step” framework in this research enabled the testing of the new model on real world construction projects. The researchers’ thesis was that introducing this model as basis for the case-studies would help structure the interviews and at the same time create feedback to the further development of the model. Figure 2 illustrates the main structure of the researchers’ assumptions about what will influence the costs. It is important to notice that this only identifies the main sources of influence and simple assumptions about when in the process these stakeholders will have significant influence on cost. It says nothing about what is most important, or more specifically what the critical conditions, assumptions and choices are.

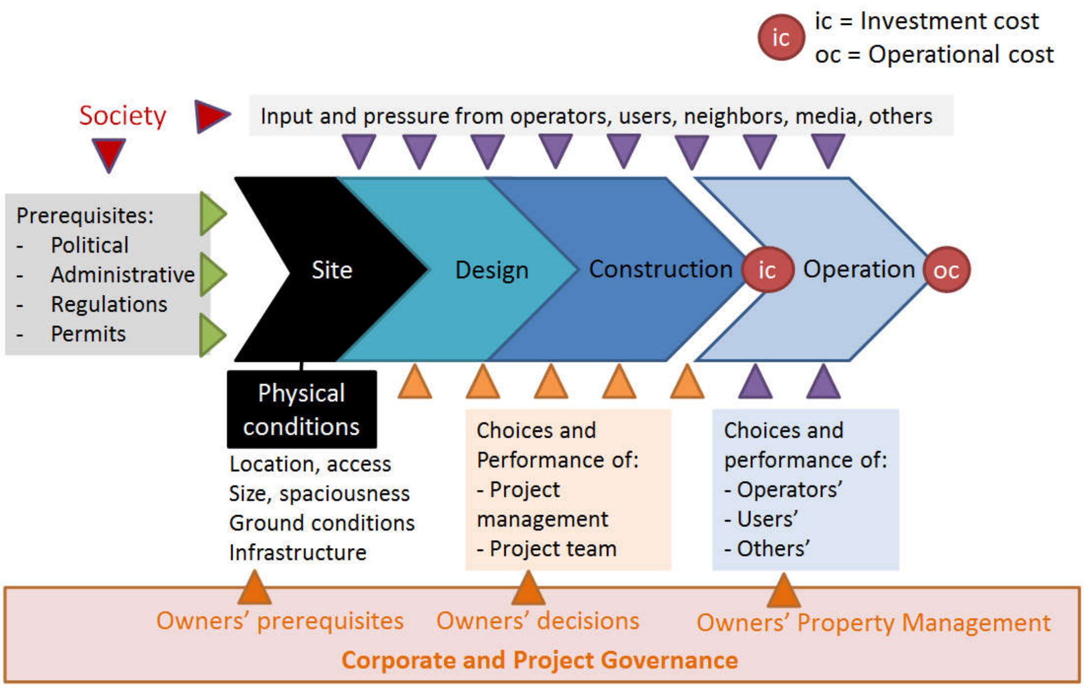


*Figure 2 - Influence patterns in construction projects and property management*

These patterns and relationships were confirmed through the interviews and subsequent analysis. Figure 3 illustrates the resulting pattern from one of the cases.

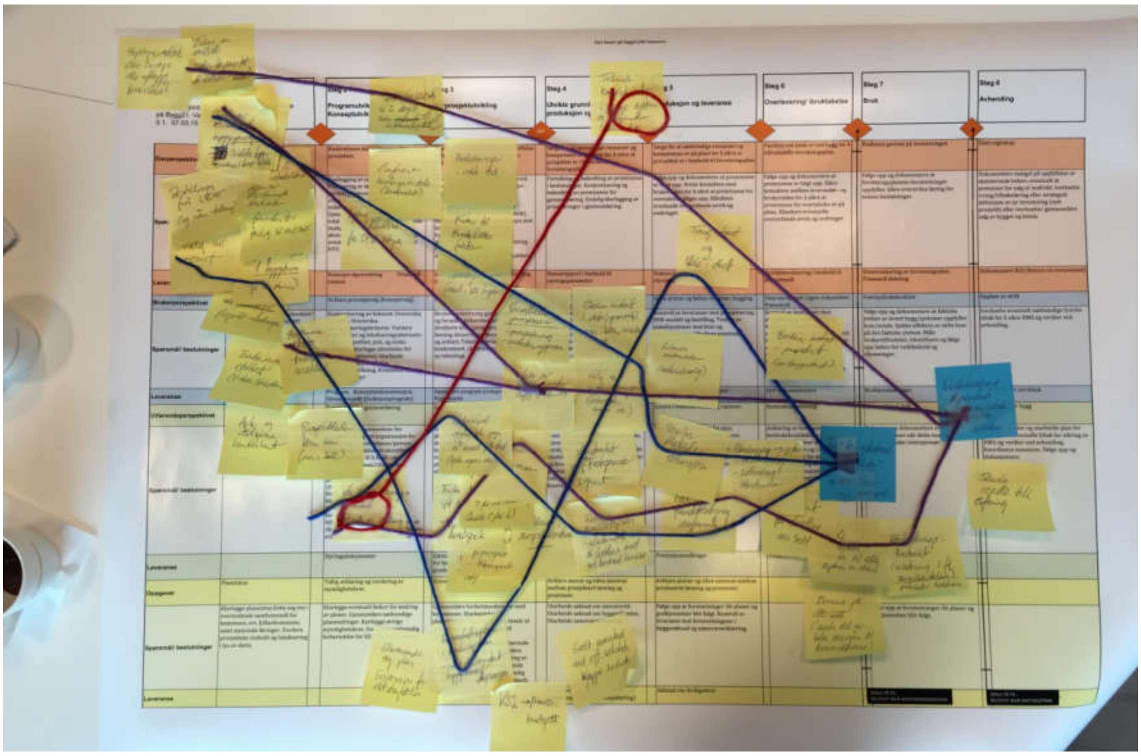

*Figure 3 - Example of case-interview result*

After the interviews, the results were drawn up as clean process diagrams that identify the important conditions and choices (yellow post-its), their interconnections (blue for investment and purple for operations) and also important reinforcing effects (red). Case descriptions were then sent back to interviewees for confirmation. A cross-case analysis is currently underway in which results from the cases are compared and analysed. Preliminary results are reported below.

**Findings**

The interviews provided a list of different cost drivers. These included expected factors like size of the project and the physical attributes of the building, technical complexity, and location, particularly with regard to the grounds and the inclusion of indoor sports arenas in two of the projects. Other factors also influenced the costs, such as standard procedures and requirements from the project owner, contract type and degree of collaboration with suppliers, as well as how user participation was organized. The findings show that different drivers and decisions were highly related. For example, spending more time on assessing the ground initially prevented later costs due to poor ground conditions. Measures to reduce energy consumption drove costs in the investment phase, but reduced operating costs. Similarly, due to extreme use of the schools, robust materials were chosen to reduce operational costs. Another example is that a collaborative approach between the client and the contractors and users, requiring time and resources initially, aids a smoother process throughout the project.

Figure 4 illustrates the preliminary cross-case analysis. We can see that main aspects of the initial model (Figure 2) are found across all three cases. Each case is given a separate coloured text (blue, red and green) and shows only those aspects pointed out of the interviewees to have been decisive for the cost in each case.

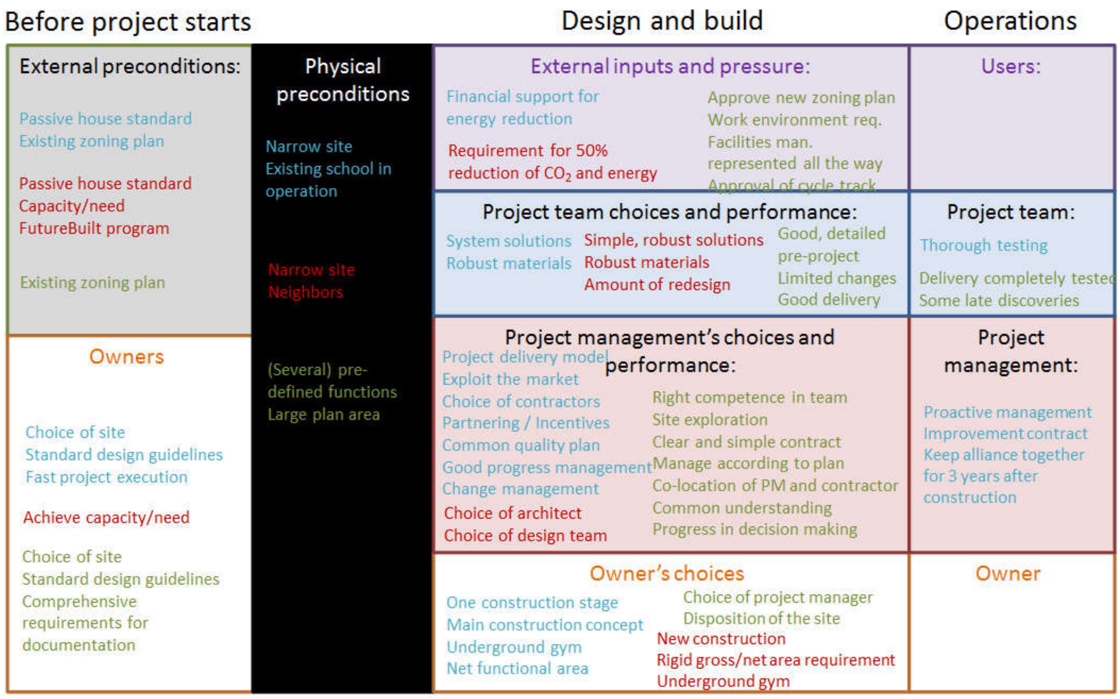


*Figure 4 - Findings from three cases in one organisation*

Careful consideration of these main observations shows important patterns within this organisation's projects. The most basic ones, and thus the source of the resulting cost level are made even before the project starts:

- External preconditions that cannot be neglected: In all cases this included the required passive house standard (political decision in the municipality), and the existing zoning plan.
- The owner's (Oslo municipality) choice and requirements: For example, choice of site is always a key to the cost (actually this works through the local conditions connected to the site itself). Furthermore, Oslo municipality has a standard design guideline, outlining quality requirements, which is always required to use in development of every project and the cost effect of this set of requirements is considered significant. In addition, the owner tends to make specific requirements for documentation, speed or capacity to each project that give each project a unique dimension.
- The physical conditions at the site are decisive in many ways, and this is one area where many projects face challenges. The technical issues and handling stakeholders are the most notable.

Next, are the choices and influences during the design and build phases:

- The choice of project manager and the main construction concept are pointed out as most important here. The area requirements are also a key to the cost, and keeping area restricted is considered an important factor both for investment and operation cost. One specific choice stands out in two of these cases: The choice to build an expensive underground indoor sports arena. The point here is that the underground area does not count against the restrictions in the zoning plan, and thus makes it possible to add enough other functions to achieve the needed capacity on a narrow site. However, it is more expensive.

- Project management makes a lot of important choices, but the main issue seems to be how the right competences are recruited to the project (architect, design team and contractors). The other main issue seems to be the project delivery model including use of contracts and adequate incentives. Partnering and key aspects of organizing the work was mentioned.
- The choices and performance made by the design team and contractors are important. Here two major factors seem to dominate: the ability to create simple and robust systems and choose robust materials that can endure rough use (remember these are all school projects).

Operations and facilities management were less focused in the interviews with project managers. This is not to say that the project managers were unaware or uninterested in operations, but the responsibility for the investment cost is closer to them and naturally comes first to mind. One interviewee mentioned that having facilities management competence represented in design and construction was a key to success, but it was considered "external" to the process. Thorough testing was held as the most important factor in projects to make sure there were no operational problems that increased cost. One of the projects used a contract that held the partnering alliance together in three years after the building was taken into use, to make sure every occurring issue would be dealt with immediately. This was reported as a success factor. Given the limited focus on operations in the initial interviews a separate group interview was held with key people from property and operations.

**Discussion**

The current study focuses on the cost side of value creation in construction projects. The findings show that the owner is in a particularly good position to create or destroy value. This complies with Klakegg (2010), who argued that early decisions and analysis have a great potential for improved value or benefit of investments. The background for this claim is that the owner (the municipality represented by the client – its professional organization for planning, building and operating schools) defines prerequisites and makes choices that decide whether the conceptual solution for the project will be the right one. This is the main aspect of value creation in construction. The value comes through using the building and from harvesting benefits in the long run. The continuous education of young kids in these schools will be the main value of these major investments in the years to come.

Project management, design management and construction management are also in key positions to secure that planning, design and construction actually create the results they are expected to do, and thus make the value creation possible. No doubt this is an important contribution to value creation.

Focussing cost in the value discussions gives project management a significant position. The design and construction phases of new schools can create expensive or cheap schools with good or bad use-qualities. Project management is vital in controlling the project development and accompanying cost. Project management develops strategies for executing the project and puts these ambitions into action. Successful project managers controls the cost and are able to create a best possible balanced trade-off between cost and desirable qualities, alternatively execute a design to cost process. One of the cases illustrates that tough requirements are not bad even if they might drive cost, as the project manager emphasises that even if the building requirements are challenging, they trigger new ideas and solutions, which is perceived positive. The findings indicate that this, in turn, is enabled by improved collaboration between the project participants, and also dialogue with the owner and users. This finding complies with the literature, which argues that stakeholder involvement is important to create value in projects, since different stakeholders have different perceptions and thus judgement of value (Knotten et al., 2016).

The "Next step" framework worked well as a "map" for discussing where on the timeline (when), and in what perspective (who's value) decisions and events during planning, execution and operations are important. It helps structure the discussions in group interviews and thus worked well as a tool for this research. The visual aid represented in the map with post-it notes for cost drivers, connecting lines and reinforcement markers also proved helpful in the interview situation. Other interviews performed without these aids provided similar, but less rich data for the analysis.

## Conclusion

The research presented in this paper makes two contributions: 1) it develops and tests a model/tool to map cost drivers of construction projects, and 2) it uses the model to identify key cost drivers and their effects, as well as the connections between them in real construction projects. The knowledge added by this research is important both from a theoretical and practical perspective. Theoretically, costs have always been on the agenda in project- and construction literature. However, we lack a conceptualization of cost drivers and how they relate to each other, as well as to the value-creation opportunities of the building. This paper is an attempt to start filling this void.

There are of course some limitations to the study, given the small sample size and the preliminary nature of the analysis. More analysis is on its way and also additional case studies. Nevertheless, we might outline some general implications for practice. Decisions makers at various levels need a tool to identify, map and evaluate cost drivers and their implications. The findings of this research, including the empirically test of the "Next step" model may aid decision makers and project managers to become aware of different drivers and how they relate to each other. This, in turns, provides a basis for making more conscious judgments and decisions with regard to costs.

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