



**KTH Architecture and
the Built Environment**

Incentives and choice of construction technique

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Licentiate Thesis

Building & Real Estate Economics
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Stockholm, April 2011

Lena Borg

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INCENTIVES AND CHOICE OF CONSTRUCTION TECHNIQUE: SUMMARY

1. INTRODUCTION

During the last decade there has been a rapid increasing interest for implementing long-term contracts with bundling of design, construction and maintenance in the construction sector in order to create incentives to build with better quality, increase innovation and decrease cost overruns. This type of contract has been increasing ever since the 1970s but has accelerated considerably worldwide after the former British Prime Minister Margaret Thatcher implemented the concept on the British construction market in the early 1990s. In Sweden this idea was however not acknowledged in a larger scale before the beginning of the 21st century when investigations of shortcomings such as quality failure, efficiency problems and lack of technical innovation in the Swedish construction sector were presented. Proposals in these investigations were an increase of longer guarantees, enhanced cooperation and more industrialised production methods to improve the sector.

The debate in recent years has focused on which type of procurement contract is the best with a focus on the incentive effects for innovation and for taking life-cycle costs into account, arguing that bundling construction and maintenance, and using more design-build (DB) contracts would improve incentives. Traditional contracts are said to not create incentives for the contractor to undertake life-cycle cost analysis and guarantee long-term functionality and also that it hampers technical development (Johansson and Svensson, 2003; Swedish Agency for Public Management, 2009). However, design-bid-build (DBB) contracts are still the dominating contract type in the infrastructure sector.

As a summary, it seems that even though there are arguments for long-term contracts and bundling of different phases in the construction chain, the sector still procure most projects with traditional DBB contracts. Is this just a reflection of conservatism or is there any rational driving force for a contract that in many people's 'eyes hampers the development and reduces efficiency in the sector?

This licentiate thesis is focusing on incentives in the construction sector both when it comes to looking at a life-cycle perspective and implementing new technical solutions, but also to what extent there are incentives even in the traditional contracts. The purpose is to contribute to a discussion about the arguments surrounding the new contract concepts where the long-term perspective of the projects, in the perspective of the contractor, will decrease quality failures, increase efficiency and open up for innovations.

In this thesis no special weight was put on partnering and financing aspects within the long-term contracts. Project partnering could be seen as a tool in the construction sector to increase the transparency and collaboration in projects and this seem to be independent of which type of contracts that are procured. Furthermore, the financial aspect isn't seen as a crucial aspect in the context of this thesis.

2. THEORY

Bundling of design, construction and maintenance as a contract package can be analysed in number of different ways. In a transaction cost perspective bundling can increase quality, technical innovation and efficiency.

The relationship between the contractor and the client is dependent on the choice of contract but also on instructions, type of compensation and forms of cooperation (SOU 2009:24). It is argued that long-term orientation enhance the performance outcome in a buyer-seller relationship and furthermore that a mutual commitment results in independent members working together to serve the customer's needs better and increase mutual profitability (Ganesan, 1994; Noordewier et al, 1990; Andersson and Weitz, 1989). The choice of contract is also crucial when it comes to responsibility and allocation of duties (SOU 2009:24).

The most general theoretical background for the study comes from theories about principal agent problems and moral hazard problems in contracts with asymmetric information (see e.g. Milgrom and Roberts 1992 for a broad introduction). It is difficult for a "principal" in the form of e.g. a client in a construction project, to create incentives and monitor an "agent" (contractor). This can lead to moral hazard problems where the agents sacrifice long-term quality in order to increase their short term profit.

Both in the academic literature (e.g. Nilsson, 2009; Nilsson and Mandell, 2010) and in some reports from leading construction companies (e.g. NCC, 2011) inefficiencies and high costs are to a considerable extent blamed on the use of DBB contracts. It is argued that a larger use of DB contracts and public private partnership (PPP) contracts would increase incentives for innovation and - in the case of PPP - reduce life-cycle costs when construction and maintenance are integrated (see e.g. Smyth, 2010; Kristiansen et al., 2005). A view that has been expressed is that DB contracts are more suitable if the client has less knowledge about what is a good construction than the contractor.

In the building sector there are several types of clients on the market, each with different perspective, goals and strategies. Some have a long run responsibility and view of the construction, e.g. housing companies that build rental housing that they plan to own a long time. Other clients have a relative shorter horizon, e.g. developers of condominiums. There is here a parallel to the infrastructure sector where the developer of rental housing is in a similar situation as the contractor with a PPP project. In the same way as a contractor with no responsibility for maintenance might choose a cheaper and, in the long term, riskier technique, a developer of condominiums is in the same situation and might be tempted to make the same kind of short term choice.

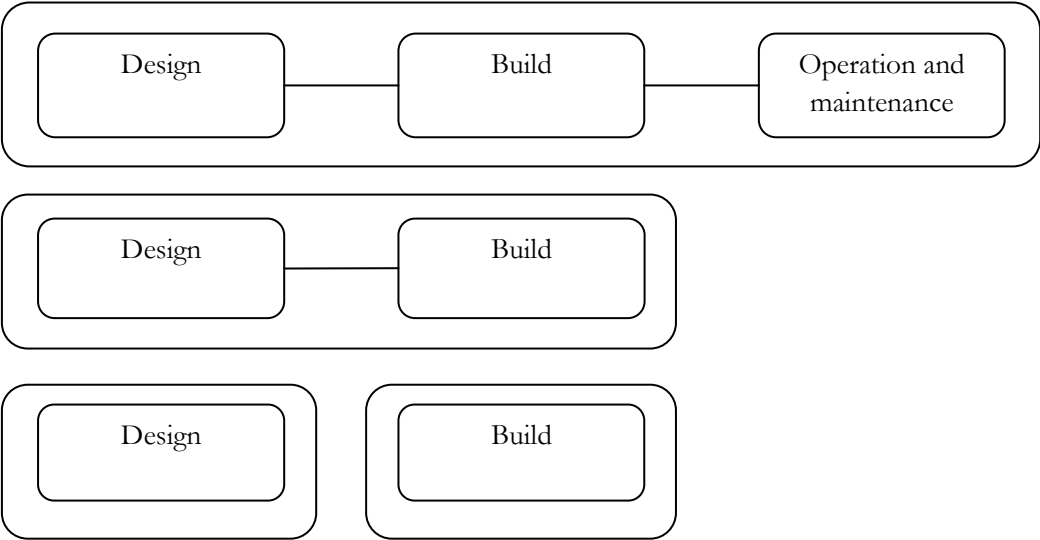
As argued in Lind and Borg (2010) -paper 1 in the thesis - it is not clear how a construction company, mostly active only in the construction stage in a diverse set of projects, can develop knowledge of the relation between construction and maintenance. On the contrary, especially the knowledge of life-cycle cost, different technical solutions and the sustainability of different materials, should point in favour of the client. Hence, a client with an interest of a long-term

perspective of their assets and a long history on the market should have built up better knowledge than the contractor, and know which technique and construction method that is best suited for its purpose. The implication would then be that DBB contracts would be more efficient.

3. RELATION BETWEEN THE PAPERS AND METHODS USED

The thesis consists of three papers. The framework and approach for all three papers was to look at the relations between different activities in the construction process (see figure 1), i.e. what is the motivation of adding operation and maintenance to construction and under what circumstances should design and construction be packaged. The three main alternatives are described in the figure: DBB contracts at the bottom with design and building as separate activities, DB contracts where Design and Building are procured together and at top, contracts where all three activities - Design - Build and Operate/Maintain - are procured together.

Figure 1: The framework of the licentiate thesis.



Paper 1 is dealing with circumstances connected to the bundling of operation and maintenance to construction. This is a theoretical paper that analyse various statements and assumptions made in the literature arguing for service-led construction. The statements and assumptions are evaluated from the perspective of different general theories, primarily standard microeconomic theory and transaction cost theory.

The second paper is a conceptual and theoretical paper with a focus on the infrastructural sector. A new conceptual framework is presented and it is argued that there also are theoretical arguments for choosing DBB contracts. This is based on transaction cost theory, focusing on both moral hazard problems and general problems with writing long- term contracts in complex situations.

Paper 3, finally, is an empirical paper that investigates if there are any indications that contractors and clients with a long-term responsibility of the facility acts differently than actors that build to sell or do not have responsibility for the operation and maintenance phase.

4. SUMMARY AND RESULTS FROM THE SUB STUDIES

4.1 Paper 1: *Service-led construction: is it really the future?*

Introduction

In recent years it has been argued that service production has higher profit margins than ordinary manufacturing. This has led to a similar discussion within the construction sector and it is suggested that the sector should move in the direction of service-led construction.

Purpose

The aim of this article is to critically analyse arguments for service-led construction and see if the implications of various statements are in line with observations in the arguments presented and in that way the article points out questions where more empirical studies are needed.

Method

The strategy is to look more closely at various statements and assumptions made in the literature on service-led construction and evaluate them from the perspective of different general theories, primary standard microeconomic theory and transaction cost analysis.

Key findings

From a microeconomic perspective services cannot in a competitive market lead to higher profits than other economical activities. Moving into services could then not be expected to increase profits in the construction sector.

Furthermore it is argued that the possibility for a private contractor to build up knowledge concerning the relation between construction techniques and operating costs is rather small. It is also problematic to assume that this knowledge easily can be transferred within the company as construction and maintenance typically is carried out by different divisions. Writing long-term contracts are also problematic in complex situations. The motivation for PPP contracts might then be more related to financing and risk allocation than to the creation of incentives.

4.2 Paper 2: *Contract types in the Swedish construction sector: Overview and theoretical analysis.*

Introduction

In 2002 the Swedish government called for a commission to investigate the Swedish construction sector and shortcomings such as quality failure, efficiency problems and lack of innovation. The result of the investigation was presented in SOU 2002:115 and the commission requested, among other things longer guarantees, enhanced cooperation and more industrialized production

methods. There are clear parallels between the Swedish debate and e.g. the debate in UK (see e.g. Egan, 1998). The debate in recent years (see e.g. Nilsson, 2009) has focused on which type of procurement contract is the best with a focus on incentive effects, arguing that bundling construction and maintenance, and using more DB contracts would improve incentives even though DBB contract still is the dominating procurement contract.

Purpose

A clear terminology is very important for a deeper discussion about the problems in the construction sector and what can be done about it. The first purpose of this article is to contribute to a better understanding of contracts in the construction sector by presenting a new way to structure the contracts. Secondly, related to the debate about which type of procurement contract is the best, the aim is to see whether there can be arguments for the large scale use of DBB contracts.

Method

A review of the debate in Sweden related to the construction sector is presented as well as transaction cost theory connected to incentives and rationality that is used in the theoretical analysis. The focus is here on the infrastructural sector, where there typically is a big government client (in Sweden, the Swedish Transport Agency).

Key findings

The relation between contract and procurement types are clarified by clearly separating two decisions – who should be responsible for design and should construction and operation/maintenance be bundled. PPP is then seen as special type of bundled contract. Many of the arguments for leaving design to the contractor and for bundling construction and operation/maintenance have a weak empirical foundation. There are a number of situations where it is logical from an efficiency perspective to choose DBB contract and this can explain the domination in practice of DBB contracts in the infrastructure sector.

Of course, there are situations where clients choose DB contracts but this is not necessarily related to incentive issues. For complex projects it might be necessary for the design and construction phases to be handled overlapping to reduce total project time. Several different techniques and designs could be the appropriate solution for the client and then competition would increase – if different firms are specializing in different techniques - when procuring with DB contracts instead. A strong client with long experience of construction and maintenance, good knowledge and resources to monitor the construction phase should be able to procure DBB contracts and take a life-cycle perspective into account. Principal-agent problems can be higher when design is left to the contractor as in a DB contract and there are also arguments against bundling construction and maintenance, e.g. difficulties in writing long-term contracts.

A long- term perspective should be taken into consideration in every project, but it is argued that this does not presuppose that the projects are procured as contracts with integrated design, construction and maintenance.

4.3 Paper 3: *Ownership, contract form and choice of construction technique.*

Introduction

The construction and infrastructure sectors have been criticised for a low level of innovations both when it comes to construction procedures as well as development of technical solutions. Also quality failures and lack of performance control systems have been debated. Bundling of design, operation and maintenance has been recommended as one way for increasing innovation and for the implementation of techniques with lower life-cycle costs. This would also imply that clients in the housing market that build to sell, e.g. condominiums, have smaller incentives to lower life-cycle costs and an incentive to choose cheaper and riskier solutions due to limited responsibility after completion, especially as they sell to a weak end-user (the household buying the condominium) that will not be able to control the technical quality of the facility.

Purpose

The aim of this article is to investigate if there are any indications that different types of clients and contractors - with seemingly different incentives – use different techniques. Do actors with long-term responsibility actually behave differently than actors with a limited shorter time horizon of the facility, i.e. a contractor that only are responsible for construction or a developer of condominiums?

Method and data collection

The key data was obtained by personal interviews with actors in the Swedish infrastructure sector for projects that were procured by contracts containing design, build and operation/ maintenance as a package. Also a survey was sent to clients in the residential housing sector that build for long-term ownership, i.e. clients that resemble contractors that design, build and takes the long-run operation/maintenance responsibility. Further a minor newspaper database search was done concerning the use of a specific risky technique to construct walls to see if there were signs that this technique primarily was used by short-term actors.

Key findings

Findings indicate that long-term contracts with bundling of construction and maintenance aren't the key to technical innovations in the construction sector. Even when the contractor is free to choose technique, they use established techniques in order to reduce risk. The study of infrastructure projects procured as integration of design, construction and operation/maintenance indicates that the contractors follow the technical recommendations and use established techniques to a very large extent. The contractors seem to be very risk-averse. The private owners of rental housing were also very risk-averse when they built new houses, only using established techniques.

Concerning the use of risky techniques there were some indications that this was more often used by builders of condominiums, but the data did not make it possible to draw more definitive conclusions.

5. CONCLUSIONS

The trend in the construction sector in general, and in the academic debate in particular, is that it is more efficient and rational to procure construction projects on broader bases, to involve the contractor in all phases in the production chain in order to create incentives to improve the sector. However, both the theoretical and empirical arguments in the thesis question this view - and indicate that the problems might not be that easy to solve thru bundling.

Contracting is difficult, especially in a long- term perspective, and it is not easy to accumulate knowledge about life- cycle costs. A long- term client should have an advantage in this respect and especially if they cooperate with technical consultants the client should be able to systematically test new techniques. Improving DBB contracts would then be at least as interesting as developing contracts with bundling.

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Paper 1

Service-led construction: is it really the future?

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In recent years it has been argued that bundling construction with operation/maintenance can increase profits in the construction sector. This idea is critically evaluated using different theoretical frameworks and the main points are: innovative organizational models only lead to higher profits in the short run, unless the firm can reduce long-run competition. Many firms should however be able to bundle construction and maintenance. Several arguments have been put forward for the proposition that bundling is more efficient, but none of them are very strong. Knowledge about the construction phase is difficult to transfer also within firms, and it is not clear how a construction firm can build up knowledge of the long-run effects of different construction alternatives. A long-run contract for certain services is—just as a construction contract—difficult to write in a way that does not lead to surprises and future problems, so the gain from this perspective is not clear. The initiative for bundling came from the public sector; it was not an innovation from the private sector looking for higher profits. The motives for the public sector seem more related to financing and risk for cost overruns and delays. Taking over risk leads to higher profits, but this is just compensation for the risk and nothing more, if it is a competitive market.

Keywords: Service-led construction, bundling, PPP, PFI.

Introduction

In recent years it has been argued that service production has higher profit margins than ordinary manufacturing; see e.g. Gebauer *et al.* (2008). This has led to a similar discussion within the construction sector (see e.g. Leiringer *et al.*, 2009) and it is suggested that the sector should move in the direction of service-led construction.

The purpose of this article is to critically analyse arguments for service-led construction. The strategy is to look more closely at various statements and assumptions made in the literature on service-led construction and evaluate them from the perspective of different general theories, primarily standard microeconomic theory and transaction cost analysis. The aim is both to see if the implications of various statements are in line with observations made, and also to try to identify hidden assumptions in the arguments presented, and in that way point out questions where more empirical studies are needed.

From the perspective of these theories service-led construction will, to put it simply, be more profitable if

it leads to greater efficiency. Two recent theoretical articles based on these theories (Bennett and Iossa, 2006; Martimort and Pouyet, 2008) show that if there is a ‘positive externality’ from investment to maintenance, then bundling investment and maintenance can lead to greater efficiency. It is then also assumed that there are information problems that make it difficult to contract directly on the relevant characteristics of the object constructed. Bundling can then also lead to more innovations.

One competing hypothesis is that bundling primarily is driven by political goals to reduce current spending and put the cost on future taxpayers instead, as the direct investment expenditure typically will be paid as a yearly fee during the period when the asset is used. A combination of financial difficulties and ambitious political goals would then explain service-led construction. Other possible explanations from a public sector perspective will be commented on in the discussions below.

The structure of the article is as follows. The theoretical frameworks are described and argued for in the first section below. After that, what we mean by service-led

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construction is clarified, and then an analysis from a microeconomic perspective is presented. In the following section efficiency issues are discussed from a transaction cost perspective. As service-led construction in many countries was initiated by the government and not by the firms in the construction sector, the motives for the public sector are discussed separately. In the final section we return to the different theoretical frameworks and their implications, before concluding comments are presented. There are also comments on other frameworks that might be relevant.

Theoretical frameworks

Service-led construction can be analysed from a number of different perspectives. As one view is that adding services led construction can lead to higher long run profits (see e.g. Gebauer *et al.*, 2008, p. 12), the first framework to use is standard microeconomic theory. The focus in this framework is on market form, level of competition but also on the difference between profits in the short run and profits in the long run. An innovation can obviously lead to higher profits in the short run for the innovating firm, but will it also lead to higher profits in the long run? Will not competition erode long term excess profits? The main question is then what has to be assumed—given the microeconomic framework—in order to conclude that service-led construction leads to higher profits, and whether these assumptions seem reasonable.

There are two weaknesses in the traditional microeconomic framework. The first is that it often makes drastic simplifications that have to be critically examined. The second weakness is that the firm is treated as a black box and that there is no explanation for why certain activities are carried out within a firm and why certain things are bought and sold on the market. As service-led construction (see next section) is related to changes in what a firm produces, and the integration between production and service activities, it is important to discuss what determines the line between what is carried out within one firm and what is bought on the market. This issue was one of the starting points in transaction cost theory in the tradition of Ronald Coase and Oliver Williamson and this is our second framework. Important issues in this tradition are how information asymmetries are handled and how incentives are created in complex organizational structures. Information and incentives are, as seen in the articles mentioned in the introduction, very relevant in the context of new organizational forms in the construction market.

All frameworks have their limitations, and a third perspective that could be used is a Schumpeterian

framework of creative destruction where dynamic processes are at the centre of the analysis. New products and organizational forms can radically change a market and one hypothesis is of course that service-led construction can be such an innovation that transforms the market. In the final section we will return to this issue.

Finally, service-led construction is closely related to decision making in the public sector as the initiative came from the public sector (see below). A deeper understanding of service-led construction then implies that there is a need for a theoretical framework related to political and public sector decision making. This could range from public choice theories to more descriptive theories developed in political science.

The concept of service-led construction

The term ‘service-led construction’ is perhaps not the best starting point, because it is, in one sense, trivial. Construction has always been done in order to produce services—driving on a road or living in a house for example. What really is in focus in the current discussion is how various activities should be grouped together. This is more of a ‘theory of the firm’ perspective where the question is whether certain activities should be integrated into one firm or produced in different firms. From the perspective of a public client, the question is whether certain things should be bought with individual contracts (and then typically from several firms) or whether they should be procured with one contract.

It is then important to identify the different activities, and in e.g. a road context at least the following activities can be identified:

- (1) Deciding about the ‘master plan’: the road shall go from A to B, using a certain route and with certain basic standards.
- (2) The detailed design of the road.
- (3) Construction of the road.
- (4) Operating and maintaining the road.
- (5) Operating and maintaining other services along the road (fuel stations, restaurants).

If it is assumed that the first activity always is done by the public sector, then there are four activities left. In the discussion about service-led construction in the road context, the last type of service is usually left out, and it is more or less taken for granted that these services are best produced by separate firms and not integrated with other activities in one firm.

Then we have three activities left—design, construction and maintenance—and theoretically they can be organized in the following ways.

- (1) *Design, construction and operation/maintenance are contracted separately.* The traditional construction contract, where the contractor builds according to a specific design that the client has made is an example of this. When the construction activities are ready, operation/maintenance is carried out by a separate firm (or in-house).
- (2) *Design and construction are contracted together; operation/maintenance is contracted separately.* This is the typical ‘design and build’ or ‘all-in-one contract’, where the same firm handles both design and construction.
- (3) *Design is contracted separately; construction and operation/maintenance are contracted together.*
- (4) *Design, construction and operation/maintenance are contracted together.*

Both (3) and (4) can be seen as ‘service-led’ construction in the sense that the contract stipulates the delivery of a certain service over a specific period of time, e.g. a road with a certain quality from the user’s perspective. Type (3) seems to be rare so the focus in the rest of the article is on type (4). If nothing else is said this is what ‘service-led construction’ stands for in this article, and this means that most forms of PPP or PFI projects are examples of service-led construction.

Can bundling lead to higher profits? A microeconomic perspective

According to standard microeconomic theory, there are no excess profits in a competitive market as free entry and competition will drive down profits to ‘normal’ levels.

This implies that:

- Temporary excess profits can arise because a firm makes an innovation (related to organization, product quality and/or costs).
- Long-run excess profits can arise if the firm has a monopoly (knowledge, patents, etc.) which in one way or another blocks entry from other firms.

If there are efficiency gains by bundling construction and operation/maintenance (an issue that will be discussed below), this could lead to excess profits for the first company that offers this combined product. This firm can offer a lower price to the customer and still make higher profits because of this greater efficiency. After a while, however, other firms would start to offer the same bundle and competition would drive profit levels down to normal again.

If bundling leads to higher profits in a longer perspective, then the explanation from a microeconomic

perspective must be reduced competition. Fewer firms might be able to offer the bundled product as it takes more resources and a larger organization to offer the bundled product.

But this raises the issue of why buyers would be interested. In order for the bundled product to be attractive, the product must—according to the textbook versions of microeconomic theory—be sold at a lower price than the unbundled products.

In the literature there are a number of monopoly-related cases where the manufacturer can ‘lock in’ the customer and make excess profits. Firms in the car industry can make more money out of services than on ‘pure’ manufacturing, as the firm e.g. can make guarantees dependent on servicing the car by the manufacturing firm. The buyer of the car can also in other ways be persuaded to continue to use the service of the manufacturer, and use ‘original parts’ because it reduces various types of risk. In other cases the monopoly aspect is also fairly clear. Sellers of console games subsidize the price of the console and earn excess profits on the individual games, as they can control the supply and pricing of such games (see e.g. Alvasi *et al.*, 2003). In the same way, sellers of printers can earn more money on selling ink because it is difficult for other firms to produce cartridges that work well with the printer.

If consumers are aware of this practice, and if there are a number of firms in the same situation, the effect would however only be lower prices on the original product and a ‘normal’ level of profit on the integrated product (printer + ink, console game + games). Only if it is assumed that the buyers are unaware of the high cost of the future services will it be possible to get excess profits in a longer perspective.

The assumption of irrational consumers might be relevant for households buying a new car, where other aspects might make the buyer forget about future service costs, but it is difficult to see how this can be relevant for construction markets. Especially for infrastructural projects, there are professional clients that always have the option to buy construction and operation/maintenance separately, and they should be expected to do this if the market for the bundled product is monopolized.

The general economic literature on bundling is rather sceptical. Bundling is often seen as strategy for a firm to make it more difficult for other firms to enter the market (see e.g. Nalebuff, 2004; Peitz, 2008). In the typical case the firm has a monopoly on good A and then by bundling A with B, the firm will make it difficult for other firms both to compete on market B and to enter market A. Arguments of this type were put forward by competition authorities in the cases against Microsoft when Microsoft wanted to integrate their web-browser into the operating system (Schmalensee,

2000). Chen (1997) shows that product bundling also can be a method to make products more differentiated and thereby reduce competition.

Olderog and Skiera (2000) argue that bundling might be motivated by price discrimination, when preferences have a certain structure: customers that have a high willingness to pay for one of the goods (but not for the other) might buy it separately at a rather high price while others with more equal preferences for the goods buy the bundle where the price of the item is only a little above marginal cost. They analyse how different structures of the preferences can motivate a bundling strategy that increase the profit of the firm.

None of these arguments seem relevant for understanding 'service-led' construction as for example there is competition both on the market for construction and on the market for operation/maintenance. The option to buy each of these separately remains. Olderog and Skiera (2000) distinguish between *pure bundling* where only the bundle is sold and *mixed bundling* where the goods are also available separately. One of their examples of mixed bundling is McDonalds that both sells 'menus' where a number of items are bundled but also sells the items separately.

The logic behind bundling can, in cases like these, be that selling a fixed bundle might reduce cost and therefore the market will be larger if products are also sold as bundles. The firm might also be better at bundling than the buyer and it is noted in the literature that almost all goods can be seen as bundled. Most people prefer to buy a computer with all parts in place instead of buying separate components and putting them together themselves.

The only plausible story so far would then be that the bundling of construction and operation/maintenance can lead to higher profits in the short run if it leads to greater efficiency, but in the long run a large part of this efficiency gain can be appropriated by the seller as new firms are able to enter the market for the bundled product. The crucial question is then how bundling of construction and operation/maintenance might increase efficiency compared to selling/buying them separately, and in the next section that issue is in focus, initially from a transaction cost perspective.

Can bundling increase efficiency?

It is, as mentioned in the introduction, easy to find statements in the general literature that after-sales services like repair, spare parts and maintenance have higher profit margins than manufacturing. This statement can be found in e.g. Gebauer *et al.* (2008) and they present an interesting description of three service strategies that can help in understanding the profit

opportunities in service production. The three strategies are:

- (1) After-sales service provider (ASP). This is the simplest case where the activities of the manufacturer and the buyer are clearly separated. The manufacturer sells a separate service package that means the product is guaranteed to function in a specific way for a certain period of time. A copying machine is a good example of this. Often different service bundles are offered. In the terminology presented above this is a case of mixed bundling as the product is also sold separately.
- (2) Customer support service provider (CSP). In this case the manufacturer also helps the buyer to integrate the product in the buyer's own processes, in order to optimize the production process of the buyer.
- (3) Development partner (DP). In this case the manufacturer and the buyer cooperate in the development of the product. The knowledge from the use of the product and the needs of the buyer helps in the development of new and better products.

Focusing on ASP, as this is closest to service-led construction, the arguments in Gebauer *et al.* (2008) suggest the following explanation:

- The manufacturer has, for obvious reasons, better knowledge of how the machine works and the characteristics of different parts of the machine. From guarantee programmes and from existing service contracts they will learn more about their own brand than for example a local firm that services a number of brands can learn.
- The manufacturer can take advantage of economies of scale in storage. Servicing a global market, they can have spare parts readily available, that they can quickly send to the place that needs it. A local firm that services many brands would have to keep a much larger storage, where many parts become obsolete, or be dependent on the manufacturer that is also a competitor on the service market. The manufacturer can easily overprice spare parts to independent service firms as it will be difficult for the local firm to find another supplier of spare parts. Rapid technological development and a continuous flow of new models increase the advantage of the integrated manufacturer/service provider.

The hypothesis is then that the manufacturer can service the product at a lower cost than a separate external service provider, and that the manufacturer therefore can earn some excess profits. As mentioned above,

competition between different suppliers of integrated packages of product and service could, however, drive the price down on the whole package to normal levels.

The argument that there are economies of scale in storage and delivery of spare parts is not relevant in the construction sector, as most advanced equipment in a construction project is bought from external suppliers. The suppliers of these products, independent of whether they supply products or products integrated with services, can supply their products both to a firm that only constructs and to an integrated firm that both constructs and operates/maintains.

Are there informational advantages in bundling?

Milgrom and Roberts (1992) present a number of information-related arguments for why bundling can be efficient.

Development of skills

The idea is that the firm while producing good A develops skills that can be used to make the production of good/service B more efficient.

Construction and operating/maintenance are typically carried out by different people using different equipment (see e.g. Leiringer *et al.*, 2009). Operating and maintenance are also in most cases carried out by a local unit, sometimes established for the specific project, and typically this unit has little contact with the construction unit that moves from project to project and from place to place.¹

This aspect does therefore not seem important in the construction case.

Information transfer

The firm that e.g. builds a road unit should have the best possible knowledge about the properties of the road. This knowledge can affect operating and maintenance in several ways. Knowing the quality of the road, it is easier to estimate the cost of maintenance, and the firm can make a life cycle optimization of costs. The firm can increase the construction quality if that reduces operation/maintenance costs considerably, or reduce construction quality if it only increases the operating/maintenance cost marginally.

This argument is, however, built on several assumptions. The first assumption is that knowledge about the construction quality is difficult to transfer to other firms. If the production process and the properties of the constructed road are documented in detail, then this knowledge could be available for all firms.

The second, and more questionable, assumption is that it is much easier to transfer this knowledge within a firm than between firms. This is, for example, assumed in the models presented in Bennett and Iossa (2006) and Martimort and Pouyet (2008). If different departments and different staff handle construction and maintenance, then it is far from obvious how more informal knowledge about how the road was constructed can be transferred to the operation/maintenance unit. The incentives for the construction unit to do this are not obvious, especially concerning things that have long-run effects, e.g. that there might be certain quality problems that the operating/maintenance unit should be aware of.

Leiringer *et al.* (2009) present an interesting case study of a large firm that works with PFI projects. They describe the organizational structure and the attitudes in this company. The firm has separate departments for construction and maintenance. The construction department has a long history of working with ordinary construction projects, and still does most of its work in such projects. For this department a PFI project is just the same as any other construction project even though it formally 'delivers' the project to another department within the same company (a PFI unit). The construction department sees itself as the most important department with the highest status. Communication between it and other departments seems to be rather weak, and Leiringer *et al.* note (p. 278) that in the construction department: 'There was little evidence of any degree of empathy with the concept of through-life service provision'. This department was also 'highly persuasive in portraying what they do as a high-value activity' (p. 278).²

The maintenance department does not have much contact with the construction department and its ability to influence design seems to be rather limited (p. 281). The maintenance department also carries out a number of traditional maintenance projects for other property owners. An interesting research issue is then how information actually is transferred from a maintenance unit to a construction unit within the private firms, and if the incentives for doing this actually are much stronger than in the public sector (see below).

The argument above also assumes that a maintenance department can build up knowledge of how different characteristics of the road affect operation and maintenance cost. With local units, operating specific roads, it is not easy for them to see the relation between how the road was built and their operating/maintenance costs. Especially in a competitive market with many firms, most of them would only have a few observations about a certain type of object and could then not draw any reliable conclusions about the relation between construction characteristics and operating/maintenance costs. We are currently studying differences in

construction techniques between ordinary projects and PPP projects and in one of the few PPP projects in the road sector in Sweden, only a handful of rather small changes were made by the PPP contractor compared to how roads usually are built.

Looking at information allocation from a general perspective, the possibilities to build up knowledge about the relation between construction characteristics and operation/maintenance costs should be better for a national road authority than for a number of competing private firms. Such an authority also has stronger incentives to commission research about life cycle costs. In Sweden a number of such projects are currently going on; see e.g. Karim (2009). When such research has established links between particular construction solutions and positive life-cycle consequences, the authority can just start to stipulate that contractors should use this solution.

The conclusion is then that it is far from obvious that private firms can build up good knowledge about the relation between construction characteristics and operation/maintenance costs.

The Swedish case studies of PPP projects presented in Andersson (2008) also show that the typical structure is that a real estate company is responsible for delivering the contracted service, but that they outsource construction to a separate company in the same way as in an ordinary construction project. To create incentives for the construction firm to take long-run effects into account, strict directives must then be included in the tender documents.

In recent years PPP-projects have also to a higher extent been sold on secondary markets to e.g. investment funds (see e.g. Leiringer and Schweber, 2010). How this affects incentives for the original investor is another important issue for future research. The hypothesis is that it weakens the incentive to minimize life cycle costs if it is difficult for the investor to measure the quality of the object, especially if the project is sold shortly after being completed.

Contractual aspects

Information problems can also make an integrated *contract* more efficient. It might be the case that it is more difficult to evaluate the quality of good A, especially more long-run aspects like duration, compared to evaluating the quality of service B. This is, for example, assumed in the models presented in Bennett and Iossa (2006) and Martimort and Pouyet (2008). If this is the case, it is easier to sell B at a price that is related to the quality. If good A is sold separately, the buyer would not be willing to pay a high price because the buyer cannot know that it is high quality product. The buyer would, however, be willing to pay a high price for a

contract that stipulates the delivery of a good service, as the quality of the service is assumed to be easier to verify. If the buyer wants a high quality product, both parties can in such a situation gain by moving from selling/buying the good to buying/selling the service, i.e. contracting directly for the characteristics that the road should have when in use.

A road is a very complex object that is expected to last a long time. It is obvious that it is difficult to write a contract that leads to the production of the 'right' object, as it might take a number of years before certain weaknesses in the construction become visible. Extending guarantees is one possibility, but as the characteristics of the object might depend on how it is maintained, conflicts about such guarantees are rather likely. The idea that it is easier to make a long-run contract on the characteristics of the service might then seem plausible, given that the characteristics of the object are more difficult to observe and verify.

In the end this is of course an empirical issue, but there are some counter-arguments to the claim that contracting on services is easier. Robinson and Scott (2009) note that the service parts in PFI/PPP projects typically list a large number of characteristics and even this large number had not been enough to get the firm to produce what the client really wanted. Their general message is that describing service quality is very difficult and that much more resources should be put into specifying service quality. Lind and Mattsson (2009), evaluating an experiment with performance-based bridge maintenance, show that there were often disagreements about whether the characteristics specified in the contract were fulfilled or not. Another problem when contracting on services is that it is necessary to specify the characteristics that the object should have at the end of the contract period, when the PPP/PFI project goes back to the public sector.

It is also well known that long-run contracts sooner or later lead to conflicts related to unexpected events and unexpected circumstances; even if partnering can reduce some of these conflicts (see Nyström, 2007).

In order to understand the development towards 'service-led' construction it therefore seems necessary to look at the development within the public sector. Why has the public sector initiated a change that leads to a structure that might not be more efficient than the earlier structure?

Why is the public sector interested in bundling construction and operation/maintenance?

Brady *et al.* (2005) and Leiringer *et al.* (2009) underline that the initiative for most of the new forms of procure-

ment comes from the public sector. If the process was driven by firms looking for excess profits by using innovative organizational forms and new contract forms, this is not what we should expect. As described in Lind and Mattsson (2009), the situation is the same in Sweden. Changes in the public sector are the driving force behind the movement towards new forms of procurement.

Let us start from a stylized version of the classical structure in the road sector. A public authority is responsible for construction and operation/maintenance of the road network. Initially they handle design in-house. Construction was outsourced to private firms as the construction works varied considerably over space and time. In such a situation it is not efficient to construct with in-house staff, even if it was done to some degree, especially in minor projects. Operation and maintenance were carried out in-house.

As mentioned above, this structure seems to have advantages from a life cycle cost perspective. The authority can, through their in-house maintenance unit, learn about maintenance costs for different alternatives. Then they should be able to transfer this information to the design and procurement unit and implement the techniques that would lead to the lowest life cycle costs.

Why was this structure changed? Disregarding purely ideological explanations, the explanation should be incentive problems in the public sector. If it is difficult to create the right incentives for the in-house departments—design and operation/maintenance—then it can be rational to try to change the structure. Putting the design aspects aside, the logical step was then to have competitive procurement also of operation/maintenance from the private sector. A detailed description of this process in Sweden can be found in Österberg (2003).

The central question is then why the public sector went from separately procuring construction and operation/maintenance to procuring them together, with a focus on the services delivered. It is, however, an empirical question to what degree projects actually are contracted on services. Our impression is that the client, beside service quality, not only contracts on the quality of the road at the end of the contracted period, but also has a number of conditions related to how the road actually shall be built. A mix of standard construction project and ‘service-led’ construction seems to be the most usual case, with—at least in Sweden—only a small part of the conditions related to service quality.

Three aspects seem to be central for the bundling of construction and maintenance, even if none of them give any final answers.

- (1) *Financial aspects.* The label ‘private finance initiative’ clearly points in this direction, but it is interesting to note that in Sweden the financial aspects have been downplayed, with the

argument that no one can borrow at lower cost than the public sector. The case studies in Andersson (2008) however show that one argument for choosing a structure where the private party finances the investment is that it is politically easier to get funding for a yearly rent than for a large investment. Projects that might not have been possible to finance in the ordinary way could be financed if they are presented as a ‘service-led’ contract.

- (2) *Risk allocation.* In several Swedish projects where the public sector has contracted on services instead of carrying out a conventional construction project, an important factor was risk allocation (see Andersson, 2008; Brunes and Lind, 2008).

The main risk that the municipalities wanted to avoid in these cases was the cost risk. They had experienced problems with construction management and cost control. Theoretically this could have been handled by a fixed price contract for the construction part of the contract, but they did not believe that this would protect them enough against the risk as the contracts still were not complete. By contracting on the future delivery of the service, all types of technical and cost risks related to the property are avoided, at least in the short run. In Sweden, the construction sector does not have the best reputation. By e.g. contracting with a real estate company about delivery of a service, the public client can reduce the risky interaction with construction firms.³

- (3) *Life cycle cost.* This has been in focus in the more theoretical discussion in Sweden. By contracting on services, the responsible contractor has an incentive to take total costs into account. As discussed above, a highway authority with a long experience of maintaining roads should, however, be able to better use their experience from maintenance when designing roads and it is not clear how the private firm quickly can learn how to design in order to reduce life cycle cost. If the project is sold after construction is completed the incentive for taking life cycle cost into account is weakened.

Blanc-Brude *et al.* (2006) have compared PPP projects with traditional public procurement of road projects. Their conclusion is that the main advantage from the public sector perspective is that budgets and time schedules were followed much better in the PPP projects. PPP projects reduce risk. They could not find any indication that PPP projects were built more expensively in order to reduce operation and maintenance

cost. The authors argue that risk aspects probably are more important than life cycle aspects for explaining PPP-projects. (A weakness in their study is however that taking maintenance costs into account sometimes leads to choosing a cheaper solution.)

Even if none of the factors above are very convincing by themselves, the combination of them can be enough for a public client to choose to write a long-run contract focusing on services.

If it is accepted that these are the three most important motives, what does this imply for the profit opportunities in the private sector? As mentioned before, one thing that creates profit opportunities is that only a few firms might be able to make the kind of long-run commitment that the service-led contracts presuppose. This reduces competition and increases profit opportunities.

Secondly, there are at least short-run profit opportunities if a private actor is willing to take risks that the public party is willing to pay much to avoid. In some of the Swedish cases, it seemed to be the case that the public party was willing to contract on a rather high fixed price for the future service, in order to avoid the technical and cost risks. If these risks are fairly easy to control for a private construction company, then the company can, at least in the short run, earn quite a high profit by taking on this risk. In a longer perspective, when more transactions are carried out, the public sector should however learn more about what is a reasonable price for this risk and more private actors would also be drawn to this market. In a longer perspective this would push profit markets down to normal levels also in this case.

Conclusions

From a microeconomic perspective services cannot in a competitive market lead to higher profits than other economic activities. Moving into services could then not be expected to increase profits in the construction sector. Large-scale projects that include both construction and long-term operation/maintenance can however lead to less competition and thereby increase profits.

If incentive and information aspects are taken into account there are certain situations where bundling of construction and service production can be expected to be more efficient, e.g. if knowledge gained during production can be used to reduce cost of maintenance or if incentives for reducing life cycle costs are strengthened. But it is not obvious that private sector firms, divided into construction and operation/maintenance units, can build up this knowledge and implement it in their projects. The incentives can also be weakened if projects are sold on secondary markets.

In order to understand the move towards bundling of construction and operation/maintenance the focus

must be moved to the public sector, as it was not a private sector innovation. The logic behind this move is however far from clear, even if a combination of financing and risk allocation seems to be the best explanation.

If this is the main explanation, and taking into account the information and incentive problems mentioned above, the hypothesis should be that service-led construction will not have many long-term dynamic effects in the form of new production technologies or organizational structures.

Contracting on services is not easy, especially in a long-run contract, and it remains to be seen how important bundling contracts will be in the future. In the general theoretical literature, bundling is looked upon rather critically, and it should not be forgotten that most construction projects are still carried out without bundling with operation/maintenance.

Notes

1. In one of the few PPP projects in Sweden—Norrortsleden—the private firm responsible for the project has actually subcontracted operation/maintenance to another private company.
2. We have gone through organizational charts available on websites and yearly reports for three large construction firms (NCC, Skanska and PEAB) and these point in the same direction as Leiringer *et al.*'s study: construction and operation/maintenance are organized as different departments.
3. This does not automatically solve all problems as is shown in the Sundsvall case study in Andersson (2008) where the municipality in the end had to pay part of the cost overruns.

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Paper 2

Contract types in the Swedish construction sector: Framework and arguments for using Design-Bid-Build contracts

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ABSTRACT

Purpose – The first aim of this paper is to contribute to a better understanding of different contract types in the construction sector by presenting a new structure. Secondly, some recent arguments for design-build and PPP- procurement systems are critically evaluated.

Design/methodology/approach – A review of the debate in Sweden related to the construction sector are presented as well as transaction cost theory, connected to incentives and rationality, that is used in the theoretical analysis. The focus is on the infrastructural sector.

Findings – The relation between contract and procurement types are clarified by clearly separating two decisions – who should be responsible for design and should construction and operation/maintenance be bundled. PPP is then seen as special type of bundled contract. Many of the arguments for leaving design to the contractor, and for bundling construction and operation/maintenance have a weak empirical foundation.

Originality – This paper presents a new way of structure construction contracts and argues that there are a number of situations where design-bid-build contract could be rational even in a long-term perspective.

Paper type – Research paper

Key Words – Construction sector, construction contracts, design-bid-build contract, design-build contract

1. INTRODUCTION

In 2002 the Swedish government called for a commission to investigate the Swedish construction sector and shortcomings such as quality failure, efficiency problems and lack of innovation. The result of the investigation was presented in SOU 2002:115 and the commission requested, among other things longer guarantees, enhanced cooperation and more industrialized production methods. The debate that followed also focused on the type of procurement contracts and the need to create incentives for innovation and for taking life-cycle cost into account. There are clear parallels between the Swedish debate and e.g. the debate in UK (see e.g. Egan, 1998).

The starting point for this article is the belief that a clear terminology is very important for a deeper discussion about the problems in the construction sector and what can be done about it. The first purpose of this article is to contribute to a better understanding of contracts in the construction sector by presenting a new way to structure the contracts.

The debate in recent years (see e.g. Nilsson, 2009) has focused on which type of procurement contract is the best with a focus on the incentive effects above, arguing that bundling construction and maintenance, and using more design-build (DB) contracts would improve incentives. Secondly, it is here instead argued that the focus should be on in what situations the different types of contracts are best. The discussion here focus on the infrastructural sector, where there typically is a big government client (in Sweden the Swedish Transport Agency), and points out that there are a number of situations where design-bid-built (DBB) contracts are rational and that it is not just a mistake that this contract form dominates in practice. As shown in Mandell and Nilsson (2010), DBB contracts dominate in this sector. In their database of 1400 road contracts and renewal projects procured by the Swedish Transport Agency (STA) less than 10% were DB contracts and the rest were DBB contracts.

The structure of the article is as follows: Section 2 contains a brief review of the debate in Sweden related to situation in the construction sector. Section 3 explains the framework of Swedish contracts and concepts within the sector. Section 4 has focus on the rationality of using DBB contracts. Finally, section 5 contains conclusions.

2. BACKGROUND

Since the investigation of the Swedish construction sector, done by the Building Industry Commission in 2002¹, several similar studies followed with roughly the same conclusions. The roles of the client and the contractor have to be developed, there is lack in quality and competition but also problems with cost overruns caused foremost by delays in the production line and thereby delays for the end users. Furthermore, it is also stated that there is low motivation of technical development, many times depending on lack of ability to utilize knowledge and take benefit of previous experiences to lower the costs (SOU 2009:24).

¹ There have been other investigations before but not as debated and discussed in media and the sector as SOU 2002:115 which is referred to here.

The culture and tradition in the construction sector is strong, the DBB contract is the dominating contract system and the public sector is the main client. The myth about the uniqueness of each project is strong and every project ends up with events that can't be forecasted and have to be solved on the spot. In addition to this, the start-up phase is short; sometimes there is only one day or two between signing the contract and the day of project start. After final inspection the staffs disperses and the team spirit and common knowledge disappears and in the next project the same procedures with new staff will be carried out. All this hamper knowledge transfer, innovation and technical development to a large extent. One big complain in the latest decades is how slow the change in the attitude in the sector are towards a more efficient and productive way of working (see e.g. Swedish Agency for Public Management, 2009).

There is often a contrast with the manufacturing industry which is seen as being characterized by detailed production planning and a strong control of the process. The subcontractor in this case is an integrated part of the total production chain and a lot of weight is put on the relationship between the actors in the network to achieve flows with high efficiency. In the manufacturing industry the productivity² and innovation development have been much better than in the construction sector and it is believed that the processes in the manufacturing sector shouldn't be that difficult to transfer into the construction sector. However, to achieve this in the construction sector, the focus have to change from a focus on a particular project to a focus at an end product and all of the processes that leads to this end product, i.e. a change in the rules of the game (SOU 2009:24). To achieve the goal of a more manufacturing oriented construction sector, clear roles has to be implemented. It is argued that the client should have the focus on the function and properties of the construction, that the activity is correct and procurement are handled in the right way. The contractor on the other hand should handle the production and development of the production phase and try to achieve large-scale production and repetition to enhance the productivity. The design and the choice of construction technique should be left to the contractor.

It is in these reports further argued that to some extent a life-cycle perspective exist in the construction sector but the sector tends to rely more upon old experience than on systematic analysis. Traditional contracts don't create incentives for the contractor to undertake life-cycle cost analysis and guarantee long-term functionality (Johansson and Svensson, 2003; Swedish Agency for Public Management, 2009). One hypothesis is then that one solution to the problem is integrating construction and maintenance in the contract and giving larger freedom to actors within such a framework, e.g. as in a Public Private Partnership (PPP).

Summing up, a general point in the debate is that the use of DBB contracts hampers development and that there are advantages with both DB contracts and PPP.

² Productivity in this context means that over time the same product or service should be produced but at a lower consumption of resources (SOU 2009:24)

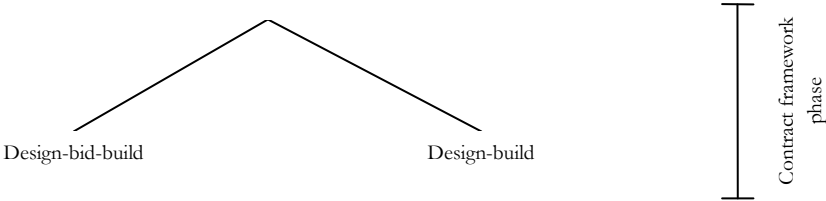
3. SWEDISH CONTRACTS: A FRAMEWORK

3.1. Introduction

It is very common in the literature to start with a rather long list of contract types: DBB contracts, DB contracts, performance-based contracts, PPP contract and other, (see e.g. Malmberg, 2003; Nilsson and Pyddoke, 2007; Nilsson, 2009). The same pattern can be found in the international literature and more practical guidelines see e.g. The US Federal Highway Administration (FHWA). Each contract type is then seen as a rather unique entity with specific characteristics, often graded in terms of additional commitment for the contractor for each type of contracts. The contract types are typically analysed in some kind of matrix given various dimensions. A further approach is where the contracts are related to the procurement strategy and can be classified by two dimensions, e.g. type of project delivery method and choice of project finance method (see Pietroforte and Miller, 2002).

Here it is instead argued that similarities and differences become clearer if different contract types are identified in a stepwise way focusing on one dimension at a time. In the first step the question is who has responsible for the detailed designs of the facility and the main categories are then (variants of) DBB contracts where it is a client’s responsibility and (variants of) DB contracts where the detailed design is the contractor’s task (Figure 1).

Figure 1: Initial decision when procuring a contract in the infrastructure sector.



The following sections will give more details about these contracts in a Swedish context and stepwise develop further levels of the tree in Figure 1 in the attempt to clarify construction contracts.

3.2 Design-bid-built contract (DBB contract)

Since the Second World War the dominating form of contract in the construction and infrastructure projects in the world is DBB contracts (Pietroforte and Miller, 2002; Love et al, 2008). The same is the case in Sweden; see e.g. Mandell and Nilsson (2010).

In DBB contracts the client has the responsibility for detailed design and construction documents and the contractor’s has to build according to the in advance stipulated construction from the client. A survey done by Eriksson and Laan (2007) shows that for the majority of projects procured as DBB contract, the client together with their consultants make the detailed design and also specify the amount of work that is required. But design could also be handled in-house by the clients using their own staff as well (SOU 2009:24). Likewise, the procured contractor for the project could build with in-house staff but also has the opportunity to procure

sub- contractors³, with no involvement from the client, if this is necessary to fulfil the client's requirements. The contractor in this case has the role as "general contractor" and takes the coordinating function for the sub- contractor/ sub-contractors but still has the full responsibility towards the client (Lejon, 2007). DBB contract procurement can also be split up in several contracts by the client instead, and the client then either coordinates the different subcontractors with their own staff or hires a project management company.

In a typical DBB contract, the client also takes the responsibility of the operation and maintenance phase that will follow, and carry the life-cycle cost of the project. Operation and maintenance can then be procured separately by the client and this contract can be similar to the DBB contract in the sense that there is a very detailed description of what the contractor should do (see Nyström, 2008).

The DBB contract can be a fixed price contract, but there might be some "variable quantities" where the contract specifies the price per unit while the payment is determined by the contracted price and the actual quantity carried out.

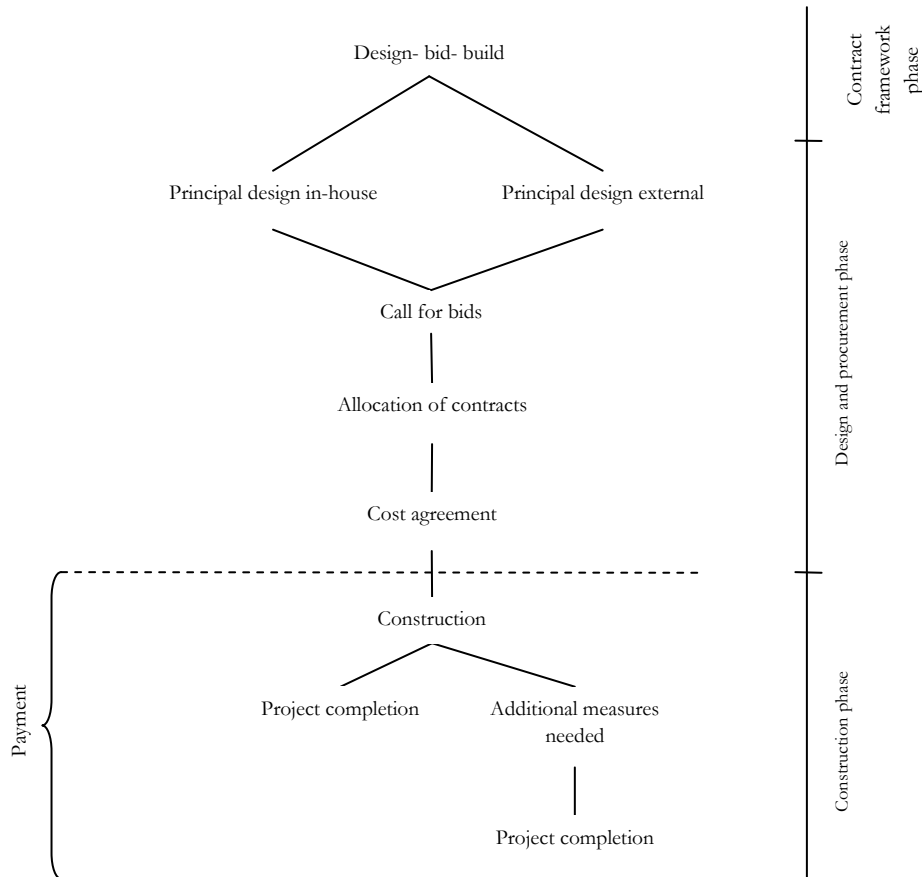
After final investigation the contract is completed and the relationship between the client and the contractor comes to an end. If any deficiencies or failures in the construction occur afterwards, allocation of correction and warrant is regulated in the general rules stipulated in AB04 "General Conditions of Contract for Building, Civil Engineering and Installation Work"⁴ of 2004. In each contract references to these rules are made and thereby they become binding for the parties. The guarantee time has typically been five years for work done by the contractor but two years for the material (Construction Contract Committee, 2005).

The process of a typical DBB-contract is described more in detail in Figure 2 below.

³ A Split contract refers to a situation where the client signs many different contracts in which each contractor has their own area of expertise and together they should accomplish the construction activities

⁴ In Swedish: Allmänna bestämmelser för byggnads-, anläggnings- och installationsentreprenader (AB 04).

Figure 2: The design-bid-build process



3.3 Design-build contract (DB contract)

The fundamental difference between DBB contracts and DB contracts is who has the responsibility for the detailed design. The beginning of the 1980s was the starting period for procuring an end product where one contractor was responsible for the whole project (integration of design and construction).

In these contracts the characteristics of the end product must be specified in some way by the client. The client has to clarify for the contractor what they want. This can theoretically be done in a number of ways, e.g. referring to earlier products ("we want a standard type of this") or by specifying general characteristics of e.g. a house; "we want a residential building in 7 floors with x square meter and fulfilling basic legal quality demands" or by specifying various functional characteristics of the object (see e.g. Bejrums and Grennberg, 2003 or Mattsson and Lind, 2009). All the different forms of DB contracts below can be "functional contracts" or "performance contracts" but also contracts where the client specifies what they want to have in some other way.

A general problem with performance contract is how the performance description and the requirements from the client can be described in measurable terms. One strategy has been to describe the properties of the facility related to performance and thereby the properties that should be maintained by the contractor (see e.g. Mattsson and Lind, 2009).

DB contract was, as mentioned earlier, procured by the properties *of the facility*. In the next step the clients make the contract more open by defining that a performance should be fulfilled *during a certain period*.

In DB contract the contractor is responsible for the detailed design as well as the building phase, i.e. the choice of production technique as well as the production responsibility lies in the hands of the contractor. The bids are submitted as a package including detailed design as well as construction.

It should be noted that the line between DB contracts and DBB contracts is far from exact. If the client gives more and more detailed descriptions of what they want, then the client comes closer and closer to doing the design themselves. The DB contract can further be distinguished according to whether it only includes the construction phase or also include the operating stage.

Only construction phase

The traditional DB contract only focuses on building a specific object. In this case, like in the typical DBB contract, the client-contractor relationship ends when the final investigation is done (see Figure 3) and failures and shortcomings related to material used and work including design done by the contractor (Construction Contract Committee, 2007), is regulated in ABT 06 “General Conditions of Contract for Building, Civil Engineering and Installation Work performed on a package deal basis”⁵ of 2006. However, there is a possibility of an extended warrant, longer than the time stated in ABT 06, and this has been seen as a way to enhance the responsibility of the contractor for the detailed design as well as for the construction. The eventual extended warrant doesn’t imply that the contractor is responsible for the operation and maintenance of the facility during that period, but only that the overall quality responsibility related to the design and construction lays in the hands of the contractor not the client during this period.

Construction and operation/maintenance

During the 1990s more long- term DB contracts started to develop, where the long- term performance of the object was specified in advance and where the contractor has the responsible for making sure that these characteristics hold during the contract period.

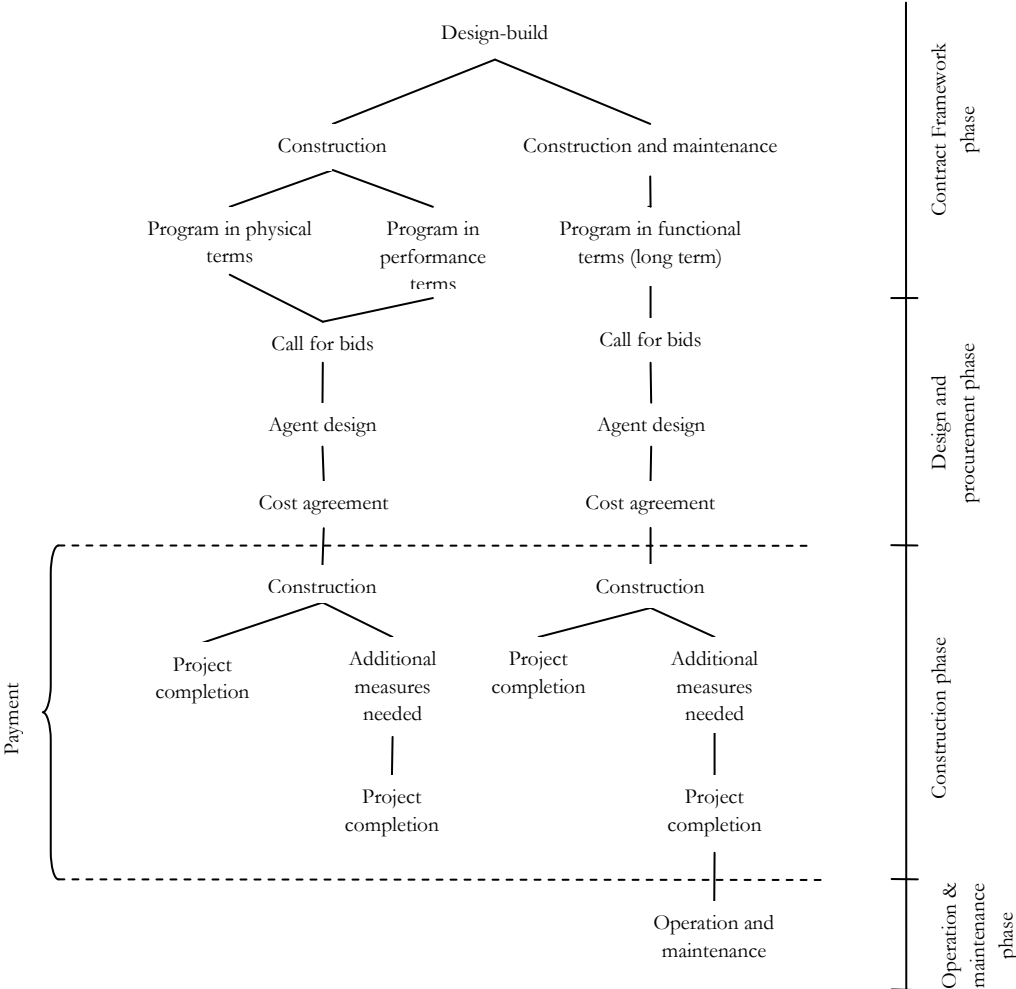
Bejrums and Grennbergs (2003) argued for expanding the already existing DB contract to involve not only the design and construction phase but also to include operation and maintenance in the contract (see Figure 3 below). It is argued that this kind of contract gives a higher degree of freedom to the contractor and the possibility to use new solutions to cut down cost and resources (e.g. Ng and Wong, 2007) but it also gives the option for the contractor to choose a solution with higher costs in the construction phase to obtain lower cost in the maintenance and

⁵ In Swedish: Allmänna bestämmelser för totalentreprenader avseende byggnads-, anläggnings- och installationsarbeten (ABT 06)

operation phase. The aim was to open up for innovative solutions and also to reduce the risk of cost- overruns, by stipulating payment in advance. Formally this contract is a DB contract with the addition of the operation and maintenance of the end product. However, the difference lies in the extent that the contract doesn't just describe the properties of the end product but also the performance of the facility that should be fulfilled during the contracted time ahead. Focus for the client will, for such a contract, be on describing the performance of the facility and the contractor's work is to make the detailed design and choose the techniques to reach the required performance during the prolonged contract period, including the period of operation.

This integration of all stages (detailed design, construction, operation and maintenance) could be seen as two parts with different payments methods, but procured at the same time and integrated in the same contract. It is possible in such a contract that the contractor gets paid for the construction phase when that is ready and then a yearly payment each year for operation and maintenance. In some forms the whole payment is a yearly payment during the period of operation - see section on Public-Private Partnerships below.

Figure 3: The design-build process



Construction and operation/maintenance: Public private partnership

Many western countries have found it difficult to find a balance between the high demand for public facilities, e.g. highways, hospitals and schools, and the financial resources available. A solution that emerged was through cooperation between the public sector and the private actors on the market and the idea to finance public facilities by private financing. This financial problem was the start up for public private partnership (PPP) procurement in many parts of the world. The common view is that PPP, under the name of Private Finance Initiative (PFI), was first implemented in the UK in late 1980s. Others, as mentioned in Leiringer (2003), looks at PPP as a concept derived back to 1970s and the Hong Kong tunnel, a BOT (Build Operate and Transfer) project. However, the notion of PPP was generally accepted first when the British government imitated it in the late 1980s and early 1990s (Leiringer, 2003). Since that time, different contractual concepts and variations of PPP/PFI have been established such as Build Operate Transfer (BOT), Build Own Operate and Transfer (BOOT).

PPP projects, and the different versions of that procurement method, are often large in scale where private actors partly or fully undertake the task of designing, financing, constructing and also operating a facility that in earlier periods would have been provided by the public sector (Leiringer, 2003). In addition, compared to a more standard DB contract, the private actor takes the responsibility of equity or/and loan from the bank, to build the public facility according to the clients functional demands stipulated in the document of inquiry. Payment for the design and construction is given during the operation and maintenance phase and could be done in many different ways, e.g. compensation for the construction phase after completion by shadow tolls and a yearly payments for the operation and maintenance until the contract period ends. Focus seems to be on the financial situation even though some researches assert the opposite (see e.g. Ng and Wong, 2007).

A central purpose of integration of all phases in the construction chain can be to give the contractor freedom of action in relation to the performance description in the contract. This can be more or less detailed. The less detailed, in how and what way to build, demands are, the more space for technical innovation and life-cycle thinking (see e.g. Nilsson, 2009; Hammami et al, 2006). As argued in Lind and Borg (2010) the explanation for the popularity of PPP contracts can also be that payments today are reduced and more of the burden falls on future taxpayers.

The actual difference between DB contracts with construction and maintenance and PPP contracts is only the financial solutions and that the construction costs are paid during the operation and maintenance phase (see further below). PPP projects are sometimes described as a special form of risk allocation (see e.g. Andersson, 2009) but risks can be allocated in the same way in a DB contract - see more below.

4. CONTRACT TYPE: IS THE LARGE USE OF DBB CONTRACTS REALLY IRRATIONAL?

4.1 Theory and the current debate

Organizations can be analyzed from different perspectives but the focus here will be on efficiency in the economic sense: how well does the organization satisfy the wants and needs of people and does it use resources in the best possible way. We try to understand the existing arrangements as efficient choices and interpret the changes in the existing arrangements as efficiency enhancing strategies. To declare an organization or an arrangement inefficient, by the definition of efficiency in Milgrom and Roberts (1992), means that there will be another arrangement that would do better for everyone in the specific situation. They also formulate the efficiency principle as a positive hypothesis: There is a tendency for more efficient organizational forms to replace less efficient.

As Mattsson and Lind (2009) mentions, changes of organizational structure and contract design can be understood from an efficiency perspective. The transaction cost hypothesis is that a specific contract or organization model is chosen after a close balance of on one hand economies of scale and on the other hand the incentives that the organization creates for the parties involved but also taking into account flexibility and handling of risk and uncertainty. Some characteristics of a transaction that are of importance and affect the organizational structure and contract design are: (Milgrom & Roberts, 1992)

- Asset specificity.
- The frequency and duration of the relation.
- The complexity and uncertainty of the work to be done.
- Difficulty of measuring performance.
- Connectedness to other transaction.

If we look in the business literature, long- term cooperation requires flexibility and emphasizes common interest and not just trying to move the risk to the other party, and also that the organization and the business process is in a need of continuous documentation (Nystén- Haarala et. al, 2010). The relationship between the contractor and the client is dependent on the choice of contract but also on instructions, type of compensation and forms of cooperation. The choice of contract is also crucial when it comes to responsibility and allocation of duties. (SOU 2009:24)

Ganesan (1994) refer to a study done by Noordewier et al (1990) that indicates that long-term orientation enhance the performance outcome in a buyer-seller relationship and furthermore points at a study done by Andersson and Weitz (1989) where the authors refer to such long-term orientation in relation to commitment. They indicate that a mutual commitment results in independent members working together to serve the customer's needs better and increase mutual profitability.

Both in the academic literature (e.g. Nilsson, 2009; Nilsson and Mandell, 2010) and in some reports from leading construction companies (e.g. NCC, 2011) inefficiencies and high costs are to a considerable extent blamed on the use of DBB contract. It is argued that a larger use of DB

contracts and PPP contracts would increase incentives for innovation and - in the case of PPP - reduces life-cycle costs when construction and maintenance are integrated.

Below we will instead explore the idea that maybe it is not just a mistake to use DBB contracts so often. Can there be an underlying rationality behind this after all? Before trying to answer that question, some clarifications need to be done concerning payment form (section 4.2). In section 4.3-4.6 the focus is on contracts for construction, and in section 4.7 contracts bundling construction and maintenance are commented upon.

4.2 DBB contracts and payment form

At least in the Swedish debate, contract form and payment form, has not been separated clearly. In Mandell & Nilsson (2010), for example, it is assumed that DBB contracts are Unit Price Contracts (contracts with fixed unit prices but variable quantities) while DB contracts are fixed price contracts (lump sum payment). As we see it whether Unit Price Contracts (UPC) or fixed payment is used in a DBB contract is a matter of risk-allocation. In both DBB- and DB contracts fixed payment can be used, but if the client believes that too much risk is put on the contractor then a fixed price will reduce competition and increase the price too much. The client can then decide to take some of the risk, related to various technical uncertainties e.g. uncertain geotechnical information. These uncertainties are e.g. very high in tunnel construction and according to colleagues in that area fixed price contracts are never used for tunnels - there is always some room for adjustment of the payment if e.g. the rock conditions are more difficult than expected. A target price contract is one form of contract that divides the risk between the parties in such a case. These complex works are also typically procured as DB contracts even if the client has a lot of technical specifications that has to be followed (see Borg, 2011).

Table 1 below summarise the options.

Table 1: Summery of options

	<i>Fixed pay</i>	<i>Variable pay</i>
<i>Client designs</i>	DBB with fixed pay	DBB with UPC element
<i>Contractor designs</i>	DB with fixed pay	DB with e.g. target price contracts

In the rest of the paper the risk allocation aspect will be put aside and the focus will be on comparing DBB contract with fixed pay and DB contract with fixed pay.

Finally it should be underlined that both these division (who designs and the payment form) are rather vague. If there are only a few variable quantities in a UPC, then it is very close to a fixed price contract. In the same way if the client has a lot of technical requirements that the contractor should fulfil, which they typically have in an infrastructure project, then the line between DBB contracts and DB contracts is also rather blurred, as the real freedom for the contractor concerning the design is rather small.

4.3 Base cases where DBB is rational

As a way to structure the discussion a base case will first be presented where DBB contracts seem unproblematic. Thereafter complications and counterarguments will be discussed.

Base Case:

Condition 1: The client has long experience of construction and has knowledge of the characteristics and effects of various technical solutions.

If this condition is fulfilled the client can decide exactly what they want and hire a contractor to carry out the work.

Condition 2: The client can monitor the work and see that it is done in the right way.

A problematic point in construction projects is to control the performance done by the contractor. However, in DBB contract where the performance of the contractor is rather well defined when almost every detail, e.g. depth of keyway, surfacing and distance are specified in measurable terms and thereby the performance can be measured. When time for final inspection arrives, i.e. it is time for delivery of completed product; this can be measured and checked according to predetermined documents. However, even though precautions have been taken by the client and the contractor obtain a pass in the final inspection, doubt about the quality is present and thereby even rather detailed work instruction has drawbacks. The client can however adjust the resources spent on monitoring to reduce this risk. As DBB contracts typically comes with a limited guarantee it is especially important that the client can monitor the contractor and observe that the work is done in the right way. An experienced client with high technical competence should however be able to monitor the right things.

Condition 2b: The possibility of monitoring can be replaced with some other incentive mechanism.

Even if it is difficult in the short run for the client to monitor all aspects of the quality of the work, the client might not be afraid of poor work standards as the client e.g. can punish the contractor with not getting any work in the future if later it is found that the contractor had done a bad job.

In Table 2 these conditions are summarised.

Table 2: Possible situations when DBB contract seems as unproblematic system.

<i>Condition 1</i>	Client has the knowledge of the characteristics and effects of various technical solutions.
<i>Condition 2</i>	Client can monitor the work.
<i>Condition 2b</i>	Client can create incentives.

As Milgrom and Roberts (1992) argue, many transactions are one-time affairs but there are also others that are repeated frequently. In DBB contracts it could be both ways, not in the specific project, but in a longer perspective, the relationship between the actors can be seen as a repeated

game as future contract situations is probable. In this case, the contractors have to take into consideration that they are in need of a good relationship to the client. This makes it risky for the contractor to do a bad job, even if it takes some time for the client to find out that the job was not done in a good way.

Given these conditions above, DBB contract seem rather unproblematic, but this is not enough to say that it is rational to use it. There must be some argument for saying that it is *more* rational to use DBB contract than DB contract.

One important argument for choosing DBB contract – also mentioned in Mandell & Nilsson (2011) - is that there might be more competition for DBB contract jobs than for DB contract jobs. There can be expected to be more firms that are able to carry out a DBB contract project compared to a DB contracts project – as in the first case they do not have to have knowledge about how to design, and don't need knowledge about how to work together with a technical consultant to make the design. Another argument, that will be returned to below, is that principal-agent problems can be more severe in DB contracts as the contractor might be tempted to choose a design that is cheaper but also more risky (see Borg, 2011).

4.4 The relative skills of client and contractor

A view that has been expressed is that DB contracts are more suitable if the client has less knowledge about what is a good construction than the contractor. This raises several issues. First, in what situations should it be expected that the client has less knowledge? When an ordinary private home owner wants to rebuild part of their house, it is obvious that the client has less knowledge than the contractor. Also when e.g. a housing company that builds new houses rather seldom wants to build, it should be expected that the client does not have so much knowledge of suitable technical solutions, especially if new materials and techniques are developed. On the other hand, a national road administration authority that has been responsible for the road network for maybe 100 years should have been able to develop a lot of knowledge about techniques and their long-term costs.

As argued in Lind and Borg (2010) it is not clear how a construction company, mostly active only in the construction stage in a diverse set of projects, can develop such knowledge. On the contrary, especially the knowledge of life-cycle cost, different technical solutions and the sustainability of different materials, should be in favour of the client. Hence, a client with an interest of a long-term perspective of their assets and a long history on the market should have built up knowledge at least as good as, or even better than the contractor and know which technique and construction method that is best suited for its purpose.

Secondly, let us for the discussion assume that the client is not so well informed about construction techniques. Several other assumption must however be made before one can conclude that a DB contract is the best.

One has to assume that there is no third alternative that might be competitive. An obvious such third alternative is that the client hires a construction consultant with good reputation, and the

client and the consultant together work out what is the best design. A consultancy firm with staff specialising in a certain construction type could be just as knowledgeable as a construction firm, and it should be mentioned that construction firms also hire external consultants in many projects. The question is then who should hire the consultant – should it be the client or the contractor?

What general arguments can one give for working with a consultant first and then hire a contractor or directly hire a contractor that also make the detailed design? From the perspective of contract theory, the risk for moral hazard seems to be larger when the contractor does the design within a fixed price contract. How can the client be sure that the contractor does not choose a design that reduces investment cost but creates risk for higher cost in the future? It should then not be surprising that clients prefer DBB contracts to DB contracts.

4.5 Who should innovate?

Several authors (e.g. Håkansson *et al*, 2006) argue that DB contracts create more room for innovation as the contractor then has stronger incentives for finding new techniques. It is however necessary to have an open mind concerning who should be the innovators in the construction sector.

Warsame & Lind (forthcoming) argues that a large client, like a national transport authority, actively must work with knowledge management and innovation in order to increase quality. This can include direct experiments, sponsoring of research and scanning what is going on in other countries.

A large consultancy firm must also work constantly with being up to date with construction techniques and what is going on in their area on a global level, and typically also cooperates with universities and doing some research on their own.

We are not saying that construction firms should not innovate, but it seems clear that a large client cannot just sit and wait for others to innovate. A construction company with a diverse portfolio of projects also have weaker incentives to invest in development of techniques for a specific type of activity. This raises the further issue of what a construction company really is: If their main role is to carry out works designed by others, then their innovations should focus on the production process, e.g. on how to put together the right team and the logistics on the building site, and not on new technologies.

4.6 Why ever use DB contracts for construction?

The arguments above seem to suggest that when there is a strong client; DBB contracts should always be used. But this is not the case, and the question is then why the strong client sometimes chooses DB contracts. Three cases are here presented where DB could be the most efficient system, see Table 3.

The first situation, case 1 in the table, is when the client is in a hurry to start the project. In a DBB contract project where the client use an external consultant, a government authority would

have to carry out two procurements and the design has to be completely ready before the client can procure the contractor for the construction activity and all this takes time. Time is saved when design and construction is procured together.

The second case, related to the first, is when it is a complex project, and where information gained early in the project will affect what is the best design in later parts. If the complete design was made before the project started, then parts of the project would have to be redesigned and this would increase costs and also cause delays.

A third situation when DB contract can be the most efficient procurement system is when the client knows that there are several different techniques for doing a certain job and that firms are specialized in one of these techniques. All these techniques work if they are carried out in a good way, and the client has no specific preference between them. If the client chooses one of these techniques, then competition will be limited and the cost higher, but if the client leaves the detailed technique open then there will be more competition as all firms can put in a bid.

Table 3: Possible cases where design and construction packaged is the most efficient system

<i>Case 1</i>	In a hurry to get the project started and completes it in a nearby future.
<i>Case 2</i>	Complex projects where design of later stages has to be adapted to knowledge gain in earlier stages.
<i>Case 3</i>	Increase the competition when there are several possible techniques and firms specializing in one technique.

4.7 Why integrate construction and maintenance?

In almost all cases, the clients in Sweden that is responsible for infrastructure write separate contracts for construction and maintenance. Today most of this work is outsourced, but with separate contracts for construction and maintenance. As described earlier, the tendency in the theoretical literature is to question this and point out advantages from an incentive perspective with bundling construction and maintenance as is done in PPP contracts.

This view is however questioned in Lind & Borg (2010) - partly based on Leiringer et al (2009) and other studies referred to in the article. The main points are:

- It is not easy for a private company to build up knowledge about the relation between construction characteristics and maintenance costs. They have very little experience of how these things are related, compared to the knowledge that an experienced client has (see also above).
- Even if a private company works both with construction and maintenance, this is typically carried out by different divisions in the company and transferring knowledge between these units are not unproblematic.

- Specifying the characteristics that the object should fulfill over a long time period is not easy as the functions that shall be delivered are rather complex. Conflicts, renegotiations and additional costs should be expected in a long-term contract in a situation like this.
- If PPP projects are sold to e.g. investment funds after a few years, the incentive effects become even more unclear as the original owner must know that it can be difficult for the buyer to know the long term characteristics of the facility.

It is suggested that the driving force behind this type of contract is perhaps primarily that more of the payment from the public sector can be pushed into the future.

5. CONCLUSIONS

From a transaction cost perspective, integration of design and construction or construction and operation/maintenance is not a well-founded solution to the shortcomings in the sector. There are a number of situations where it is logical from an efficiency perspective to choose DBB contract and this can explain the domination in practice of DBB contracts in the infrastructure sector.

There are many different types of clients and contractors with different levels of knowledge and competence. A strong client with long experience of construction and maintenance, good knowledge and resources to monitor the construction phase should be able to procure DBB contracts and take a life-cycle perspective into account. Principal-agent problems can be higher when design is left to the contractor as in a DB contract and there are also arguments against bundling construction and maintenance, e.g. difficulties in writing long-term contracts.

Of course, there are situations where clients choose DB contracts but this is not necessarily related to incentive issues. For complex projects it might be necessary for the design and construction phases to be handled overlapping. Several different techniques and designs could be the appropriate solution for the client and then competition would increase – if different firms are specializing in different techniques - when procuring with DB contracts instead.

A long-term perspective should be taken into consideration in every project, but it is argued that this does not presuppose that the projects are procured as contracts with integrated design, construction and perhaps maintenance.

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Paper 3

Ownership, contract form and choice of construction technique

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ABSTRACT

Purpose – The aim is to investigate if there are any indications that different types of clients and contractors in the construction sector, with seemingly different incentives, use different construction techniques.

Design/methodology/approach – The key data was obtained by personal interviews with actors in the infrastructure sector but also by a survey and newspaper database search. The survey was directed to clients/ builders in rental multifamily housing companies.

Findings – Findings indicates that long- term contracts with bundling of construction and maintenance aren't the key to technical innovations in the construction sector. Even when the contractor is free to choose technique, they use established techniques in order to reduce risk. However, there is some support for the statement that more risks are taken by a builder when they plan to sell to weak clients like households buying condominium.

Originality/ value – The paper provides empirical evidence and questions a number of statements concerning the behaviour of contractors in the context of long-term contracts in the construction sector.

Paper type – research paper

Key words – Construction sector, long-term contract, technical innovation, rendered stud-walls

1. INTRODUCTION

The construction and infrastructure sectors have been criticised for a low level of innovations both when it comes to construction procedures as well as development of technical solutions. Also quality failures and lack of performance control systems have been debated. Bundling of design, operation and maintenance has been recommended as one solution and the literature within the field are arguing that knowledge transfer between different projects and within firms will give an incentive to use solutions more suitable in a life- cycle perspective. Such a bundling could increase the quality within the sector when the contractor has the responsibility for a longer period. This is mentioned in many studies e.g. Bennet and Iossa (2006), Martimort and Pouyet (2008) and Nilsson (2009) but also questioned by e.g. Leiringer *et al.* (2009) and Lind and Borg (2010).

The residential multifamily housing sector has a long history of different types of firms. Some property owners build rental housing that they plan to own for a long time, but there is also a big sector with developers of condominiums where the long term responsibility of the developer and builder is rather small. A recent survey, done by Svensk Byggtjänst (Swedish Building Center) in 2010 reveals that actors within the construction industry take life- cycle cost into account in a poor way. It is argued that the process is characterized by a choice of cheaper and riskier solutions in order to lower the production costs, even though the life- cycle costs might be higher. This resembles the debate about the effect of short-term construction contracts and it is tempting to say that clients that build to sell, e.g. condominiums, have smaller incentives to lower life- cycle costs and thereby choose cheaper and riskier solutions due to limited responsibility after completion, but also that they are in a relationship with a weak end-user (the household buying the condominium) that will not be able to control the technical quality of the facility.

The aim of this article is to investigate if there are any indications that different types of clients and contractors - with seemingly different incentives - actually build differently. Do actors with long- term responsibility actually behave differently than actors with a limited shorter time horizon of the facility, i.e. a contractor that only are responsible for construction or a developer of condominiums?

The hypothesis can be formulated in two ways; first, bundling of construction and maintenance creates incentive for a contractor to implement new techniques and materials to a larger extent than the conventional contracts due to incentive of lower life-cycle costs. Second, the hypothesis is that companies that build to sell tend to use cheaper and riskier technical solutions to a larger extent.

This article is based on interviews with clients and contractors in Sweden where the project is procured contracts containing design, build and operation and maintenance as a package. Further, a survey was sent to clients in the residential housing sector that build for long-term ownership, i.e. clients that resemble contractors that design, build and takes the long- run operation and maintenance responsibility. A minor case study concerning the use of a specific risky technique to construct walls has also been made. Due to the small and selective samples of these studies the results should primarily be seen as indicative and as a starting point for further

work in this area. In the theoretical literature there are many statements about effects of e.g. different procurement forms on innovation, but surprisingly few empirical studies can be found in the literature.

The structure of the article is as follows. Section 2 contains a short practical and theoretical background. Section 3 describes the methodology that was applied in this study. Due to the fact that bundling of design, build, operation and maintenance is said to create new innovative technical solutions, the result of interviews with contractors and clients of projects of this procurement system is presented and discussed in section 4. In section 5 results concerning the housing sector is presented, both results from a survey of 51 clients in the residential housing construction market and the case study of the criticised “render on wooden stud-walls”. Finally, section 6 contains the conclusions.

2. THEORETICAL BACKGROUND

The practical background to the study is, as mentioned in the introduction, statements about low motivation for innovations and for improvements in the construction sector, and lack of incentives to use new techniques. General problems in the construction sector have been discussed in many countries (see e.g. Egan, 1998 and SOU 2002:115). Lack of trust and other incentives problems are discussed in a number of works, e.g. Ng et al. (2002), Eriksson and Laan (2007); SOU 2009:24.

The most general theoretical background for the study comes from theories about principal agent problems and moral hazard problems in contracts with asymmetric information (see e.g. Milgrom and Roberts 1992 for a broad introduction). It is difficult for a "principal" in the form of e.g. a client in a construction project, to create incentives and monitor an "agent" (contractor). This can lead to moral hazard problems where the agents sacrifice long- term quality in order to increase their short term profit.

This type of argument leads to the hypothesis that long- term responsibility of an asset affects the technical solutions, increases the technical development and encourages innovation in order to overcome the shortcomings in the sector (see e.g. Kristiansen et al., 2005). To create this long-term responsibility new concepts has been introduced were bundling of design, construction and maintenance as one package has been presented as a way to improving the performance of the sector and open up for new and better techniques (see e.g. Smyth, 2010). Partnering contracts, contracts focusing on functions and public private partnership contracts (PPP) are examples of this. Leringer (2003) argues e.g. that PPP projects do support technical innovation but to achieve this, the right conditions and actions are of importance. However, Leringer further points that PPP in itself doesn't nourish innovative behaviour more than a traditional contract, e.g. design bid build (DBB) contracts and design build (DB) contracts.

A central purpose of these long-term contracts is, as mentioned above, to give the contractor the opportunity for freedom of action. The client should formulate more or less detailed functional

description in the contract, but leave the solution to the contractor. The motivation for this is that the less detailed demands stipulated, the more space for technical innovation and life-cycle thinking and thereby a possibility of, for example, spending more money in the construction phase and in turn lower the future operation and maintenance costs (Nilsson, 2009).

In the building sector there are several types of clients on the market, each with different perspective, goals and strategies. Some have a long- run responsibility for the construction, e.g. housing companies that build rental housing that they plan to own a long time, and some have relative shorter horizon, e.g. developers for condominiums. There is here a parallel to the infrastructure sector where the developer of rental housing is in a similar situation as the contractor with a PPP. In the same way as a contractor with no responsibility for maintenance might choose a cheaper and, in the long term, riskier technique, a developer of condominiums is in the same situation and might be tempted to make the same kind of short term choice.

3. METHOD

As the focus of this study is to look for indications that contractors and clients with a long- term responsibility of the facility acts differently than actors that build to sell or do not have responsibility for the operation and maintenance phase, no special weight will be put on the specific procurement methods and financing aspects. Neither will detailed technical descriptions be discussed or evaluated, even though some techniques will be mentioned. In this section the methods used and also the problems we ran into will be described.

Three different approaches are applied in the attempt of finding indications that incentives affect the choice of construction techniques in the house building as well as the infrastructure sector. Section 3.1 describes the approach regarding the infrastructure sector and 3.2 the approaches used for the housing section.

3.1 Infrastructure study

In an international perspective bundling, PPP, Performance contracts etc have been applied to e.g. road projects, schools, and prisons. Contracts with bundling of construction and maintenance are, however, rather rare in the infrastructure sector in Sweden and the method used in this part of the study was semi- structured interviews with people involved in some Swedish infrastructure projects. The focus in the interviews was on how the contractor had used the freedom concerning choice of construction techniques. For one of the projects the information from the contractor was giving under the condition that it should not be possible to identify the project. To fulfil this demand no details will be presented concerning the projects and no information will be given concerning technical details.

3.2 Housing construction study

Several approaches were tried to get information about how different incentives affect choice of construction techniques. During the last decades rendered stud-walls have been a popular façade technique. The construction technique reduces cost but has been shown to be sensitive for moisture (Samuelson and Jansson, 2009) and have led to problems in a number of housing projects. A big national survey done by Samuelsson and Jansson in 2009 aimed to investigate, amongst other things, the extent of this construction failure.

In the context of long- run responsibility the idea of this study was to see if there were any indications that this less costly solution but more risky solution was more commonly used amongst builders that don't have a long-term responsibility of the project. More specifically, was this technique more often used by developers of condominiums and single family houses compared to developers of rental homes with a long- run time horizon?

The initial idea was to use the data collected by Samuelsson and Jansson (2009), but it turned out that ownership category had not been registered. The second idea was to focus on specific areas and see if any correlation could be found in these areas between choice of technique and ownership category. However, statistical information from municipalities and organisations did not exist and then we tried to gather information by visits to the municipality archives and create a data set. Even here problems occurred due to difficulties of identify the technique from the material. Finally two approaches were used. A search in a database of newspaper articles published 2007-2010, i.e. the years following after the discovery of the moisture problems in rendered stud-walls in Sweden, was performed. The idea was to see if they reveal any pattern of tenure forms in the use of this rather newly introduced technique for facades. 49 articles were generated from the search criteria with the following Swedish key words: "enstegsfasad" or "enstegstätning" or "enstegstätad".

A survey was also sent to clients in the rental housing sector to investigate how they look at this new technique but also to get an indication of how the actors that builds for their own management look at new techniques and their perception of choices made by other ownership categories. The survey was sent to 51 private as well as municipal housing companies. The survey was conducted during October 2010 and can be seen as a whole in appendix 1.

4. INFRASTRUCTURE PROJECTS

4.1 Introduction

Large infrastructure projects in Sweden are procured by the Swedish Transport Administration (STA) and they have formulated a large set of norms and technical regulations for different types of projects and these direct all actors on the market. When procuring DBB contracts or maintenance contracts, the document of inquiry refers to these rules and regulations. In the newer contracts with bundling of construction and maintenance, an attempt is made to open up for the contractor to choose their own technical solution given the performance standard

formulated by the client. In this section the experiences from long- term contracts within the infrastructure sector are presented, based on interviews with both clients and contractors. As mentioned above some of the information was given under the condition that the project could not be identified so the description will be rather general.

4.2. Reflections of the interviewees

There is a willingness, but still a limping willingness, to change the Swedish infrastructure sector in order to increase productivity and quality. More and more performance related contracts are procured and the functional demands that are stipulated in the documents of inquiry create a possibility for the contractor to choose the technical solutions that achieves the required function of the facility. The interviewed persons think that this idea is good, but it is more convenient for the contractors to continue to fall back on the traditional norms and regulations. The established technical solutions are tested and reliable, and thereby the risk for large problems are minimised, e.g. mistakes in the dimensions of a new technique.

The technical norms and regulations are based on knowledge gathered over many years of constructing, operating and maintenance of the infrastructure and the interviewees are showing great respect for these traditional solutions. There are many well- advised technical solutions and a lot of problems might occur and could be very costly in the operation phase if changes and experiments with new techniques are made. The basic instinct, even though innovations of technical solutions are of importance and something to strive for, testing it on complex components as bridges, railways and tunnels could be irresponsible and could lead to failures and fatal consequences. Such repercussions must be taken seriously and for the interviewed clients risk averseness is the leading concept.

People involved in this type of big infrastructure projects are saying that the demands stipulated in the inquiry differ much in detail, from more general and not so verifiable design demands to very detailed design demand. This leads to a view that it is easier to use the already accepted solutions in order to get easier verifiable performance and functions. The verification of a functional demand is something that the clients, according to contractors, have to increase their knowledge about. If there are difficulties concerning verifiability, then it is even more risky to come up with new technical innovations.

In the general discussion actors in the sector are saying that performance contracts create an incentive for the contractor to use their own techniques and materials. However, the contractors interviewed underline that a smoother cooperation with the client is achieved if they work with well known solutions and materials rather than implementing new alternatives. This makes it important for the contractor to weight the advantages against the disadvantages of a new technique and material.

When it comes to material and systems in the functional demands, they are in reality pointing in the direction of which product to choose without saying it explicitly, i.e. the degree of freedom might not be as wide as STA officially says in the procurement phase. For example, demands are saying that the system in the current project should be compatible with other already existing

surrounding systems and that the standard should be at least as good as the already existing one. However, by looking at the different construction components the norms are to a larger extent referred to when it comes to more complex parts. According to the experience of the interviewed contractors roughly 80-85 % is contracted according to the norms when it comes to really complex components such as bridges and tunnels, less complex parts could be controlled to a smaller extent.

In the theoretical discussion it is often said that long term contracts e.g. PPP and performance contracts, creates strong incentives to design and implement new and better technology and in that way enhance the quality in the sector. Beside the arguments about risk presented above, the interviewed persons underline another aspect - the size of the project. It is e.g. not cost efficient to have an in- house operating organisation that only has responsibility for a couple of kilometres of for example a road. It is then rational to use the same external company to maintain the road as is used in neighbouring districts and this also reduced the room for innovations.

In one of the studied projects there were a few minor changes compared to the traditional way of building motivated by life-cycle costs. This were both cases where quality was increased to reduce operating and maintenance costs, but also the opposite, a more simple solutions where the reduced investment cost compensated for the shorter life span of the components.

The overall experience from the interviewees is that the document of inquiry connected to this type of contracts does not have explicit specification on how actually to build. Only broad outlines are stated and references to minimum standards both to surrounding roads, railways and platforms as well as norms and regulations. In practice the established techniques and materials are however used to a very large extent and the main explanation for this is that it reduces the risk for the contractor.

5. RESIDENTIAL HOUSING CONSTRUCTION

In this section results concerning the risky technique for the construction of façade are first presented and then the more general views on differences between different types of construction clients. In both sections information from the questionnaire is used. The survey was conducted during October 2010 and was sent to 51 clients acting on the rental housing market, 32 municipality companies and 19 private companies. Of the 51 clients, 27 responded to the survey which means a response rate of 53 %; for the municipality companies the response rate was 76 % and for private companies 24 %. Of the respondents approximately 92 % have been working in the sector for 10 years or more and are working as project manager ("projektledare"), head of real estate ("fastighetschef") or head of the technical department ("teknisk chef").

5.1 Façades

5.1.1 *The background of rendered stud- walls*

The method of render on insulation was developed in Germany during the middle of the 20th century and was a big success and contained render on brick- walls as an additional insulation and was introduced in Sweden in the early 1970s. During the 1970s the period of “render on wooden stud-walls” started in North America and got the name EIFS, Exterior Insulation Finishing System. In Europe, including Sweden, the system got the name EITCS, External Thermal Insulating Composite System, when it was introduced in the beginning of the 1980s.

During the last ten years, large-scale moisture damages have been discovered on buildings that have been constructed with the above insulation system in Sweden. However, in North America the system was questioned as far back as in the end of the 1980s due to the observation of notable moisture damages in walls that had been insulated with the system. A considerable number of the inspected objects had an extremely high moisture level including mould accretion and bacteria on the gypsum board, laminated wood or chipboard. There have been several explanations of the high moisture levels as well as the underlying cause of microbiological accretion. The most probable explanation is that water is penetrating thru defective connections and other leaks in the façade during pelting rain, in combination with organic material in the wall. (Samuelson and Andersson, 2009) The system was aimed to be used on heavy constructions e.g. concrete and bricks frameworks, where this accretion was almost impossible. During the 1990s, 80 000 condominiums in Canada were reported to be affected by mould as a consequence of this type of wall system (Villaägarna, 2011). Since the first alarm of moisture in rendered wooden stud- walls in Sweden in early 2001¹ the debate has intensified (see Nordberg 2009; Forsström 2010; Berglund 2009; The Moisture Research Centre Lund, 2007) and numerous multifamily houses as well as single family houses was reported to have moisture problems.

5.1.2 *Database survey*

The hypothesis to be investigated is that clients with a long- term responsibility of a house focus on using more established techniques and want to lower the risk of a failure in the construction even if this increases investment costs. They are expected to look more at the life-cycle costs of a housing construction, and should then be expected to avoid the technique with rendered wooden stud-walls described above. This technical system should more often be adopted by those clients that sell the product shortly after production.

If this is true then the render on wooden stud- wall should more often be observable in the construction of tenant owned condominiums and single family houses. As described in section 3.2 there were problems with getting more direct data on this so more indirect methods were chosen.

A search in a Swedish newspaper database (Mediaarkivet Affärsdata) gave a result of 49 articles between 2007 and 2010, the years when the media sector started to pay more attention to this

¹ SP (Technical Research Institute of Sweden) reported in 2002 about moisture problems in new built multifamily houses in Hammarby Sjöstad, Stockholm region. (Villaägarna, 2011)

problem in Sweden. A study of these articles show that nineteen of them concern involvement of either tenant- owned condominiums or single family houses and just four articles concerned rental housing. In 55 % of the articles it was impossible to figure out the type of tenure in the project.

Contact was also taken with SABO - the organization of municipal housing companies - to ask whether rendered stud- walls has been used in the municipality companies stock. The hypothesis was that this would not be the case. The informant, however, said that there actually were cases where this system had been utilized in the municipal stock, but typically this were cases where the client had procured the project as a DB contract. In some of the DB cases the winning company primarily produced condominiums and then used the same technique in the rental houses as in their own condominiums.

As mentioned earlier, the information collected does not make it possible to make a more formal test of the hypothesis that the technique with rendered stud- walls was more often used in condominium projects, but the information collected is at least consistent with this hypothesis.

5.1.3 Clients view on rendered stud-walls

The survey that was done for this study with private and public clients in the rental housing market shows that 52 % have had experience of this system and that 75% of those with experience belonged to the public sector (Figure 1). It is interesting to note that private developers of rental housing are those that seemed to have avoided the technique to the largest extent, and this is also the group with the strongest incentive to take long-term consequences into account.

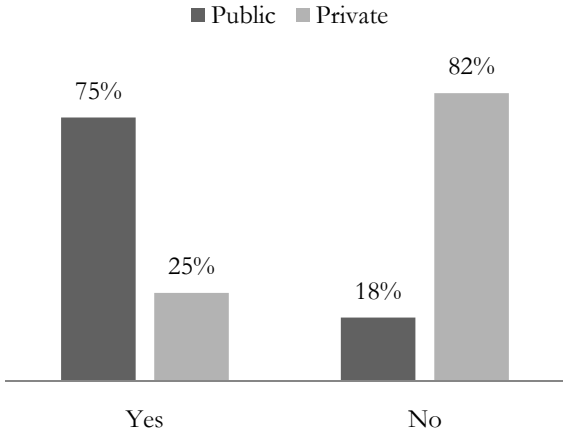


Figure 1: Experience of rendered stud-walls distributed by sector.

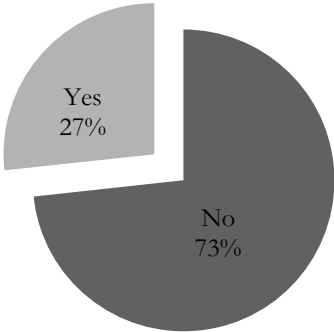


Figure 2: Share of those with experience of the technique that experienced problems.

Interesting to notice, out of 52 % that have had the experience only 27 % said that the system had created problems for them, but mostly minor problems and 73 % of them are saying that they had not experienced any problems (Figure 2).

The respondents confirmed what was previously said concerning that the rendered stud-wall system works if it is done on heavy framework but should be excluded if the technique isn't used in a faultless way. Hence, the private client that have had the experience are saying that they haven't had any problems with it, referring to what was previous said about the importance of the quality of construction, but also indicated that problems might come.

An observation is that 50 % of the responding clients that are situated in the southern part of Sweden has experienced big or at least some problems with the technique while the ones in the middle and north part mostly have none or small experience of problems with this system. This is in line with the results from Samuelson and Andersson (2009) which indicated, both from reported damaged buildings as well as from a random sample of buildings investigated by the authors, that the most affected constructions are situated in the south and south-west part of Sweden.

Of those that haven't had any experience of this specific system, 49 % of the respondents, all of them are pointing at the weakness of the system that have been shown by investigations and discussed within the sector, as well as in the newspaper, and with that as background these respondents have thereby chosen a safer solution.

5.2 Clients view of implementing new technical solutions and choices of material

The survey also asked some more general questions about choice of techniques and experience of different techniques. The survey reveals that 57 % have used a technique during the last 10 years that have shown to be a bad solution and even have regrets having used it. This result is independent of client type, i.e. independents of whether or not the respondent is from a private or public company. The questionnaire contained open questions where the respondents could add comments. The comments that were received show that the main reasons for regrets are related to the above discussed system of façades with the rendered stud-wall. 60 % are saying that their regret concerns this specific implemented system but also pointing at ground plate of concrete "platta på mark" and constructions where the failure can be related to the choice of material in combination with bad construction. 53 % of total respondents have regrets about the choice of material but they are flagging for the combination of bad construction together with wrong material that could be the explanation of failures in the construction.

The respondents were asked about constructions and choice of material done by others within the sector; if others have chosen solutions that the respondents wouldn't consider using. 50 % said that there are activities that others have done that they would not use themselves due to observed failures. The comments to this question are pointing at three troublesome construction areas: façades with thin plaster "tunnputs", wooden façade "träfasad" and wooden framework "trästomme". These doubts are highly correlated to the risk for high maintenance costs. 53% of the public respondents have done this reflections compared to 40% of the private. When it comes to views on other actors within the market the survey reveals that the public companies to a bigger extent have views about what others have done.

Questions were also asked about their general attitude to new techniques and how they select new techniques. The result in figure 3 below shows that there is a general carefulness regarding implementing new techniques and materials in projects. In the private sector it seems that they are even more careful than the public and looking at tests done by the manufactory industry, but also leaning on which solutions and material others within the sector have used, and learning by their success/ failure. In this matter the public companies are more heterogeneous. Some of these companies want to be in the frontline of implementing new techniques but also want to lean on tests by others or by the manufacturing industry. But a small group of the respondents (17%), only public clients, do in-house tests in a small scale before they apply the technique on their own projects.

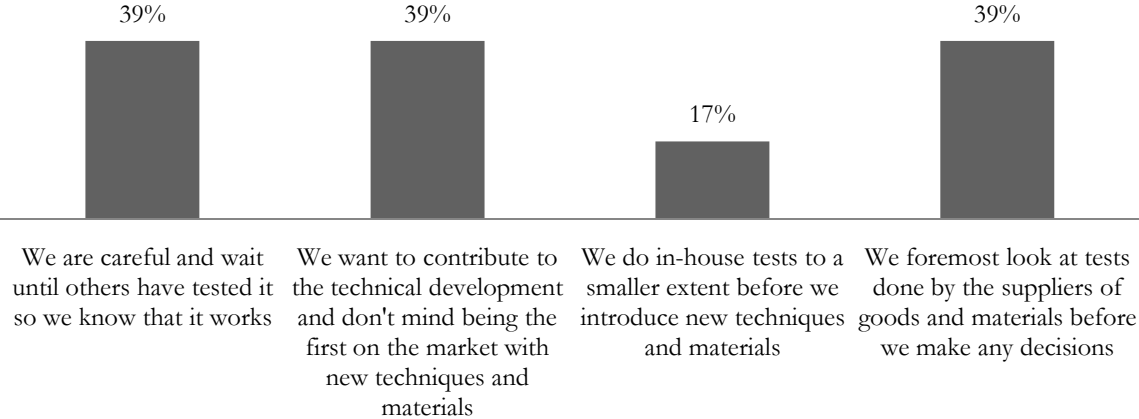


Figure 3: The general view of implementing new technique and new materials.

The survey also investigates what the respondents thought of some specific construction techniques, e.g. rendered stud-wall (see section 5.1 above) and wooden framework. In later years there has been a debate about alternatives to concrete in the framework, partly related to the climate discussion (see Gustafsson *et al.*, 2005; Bowyer *et al.* 2005). Using a wood frame in buildings would contribute to a reduction in the emission of carbon dioxide. The respondents are not in general negative to this alternative, however, approximately 30 % (see figure 4 below) are saying that they haven't any plans to use it with the argument that there are too many moisture related failures with this construction, i.e. the risk of this framework system is judged to be too high. Also in the context of fire and acoustics they prefer heavy constructions instead of light weight constructions. But 39 % are saying that even though they haven't used it they are thinking of it as an alternative. However, of the 30% of the respondents that have built with this framework, all seems in general to have a positive experience. Regarding cost savings connected to this construction system, the opinions differ a lot. Some respondents are saying that there is savings that can be reached within this system and then especially when it comes to laying the foundation, but on the other hand some are saying that the total system is too expensive. These differences in opinion also reflect difficulties in predicting the effects of new techniques in a longer time perspective.

43% of the respondents partly agree that new technologies are motivated by lower costs. 13% totally agree (figure 5). Those that totally or partly agreed were in majority in the public sector (see Appendix 1). As many as 80% of the private respondents had no opinion.

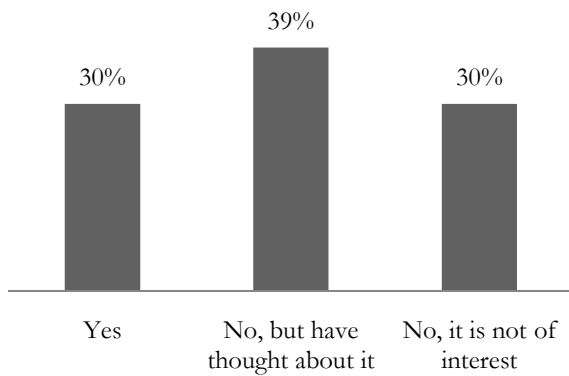


Figure 4: Using wooden frameworks instead of concrete frameworks.

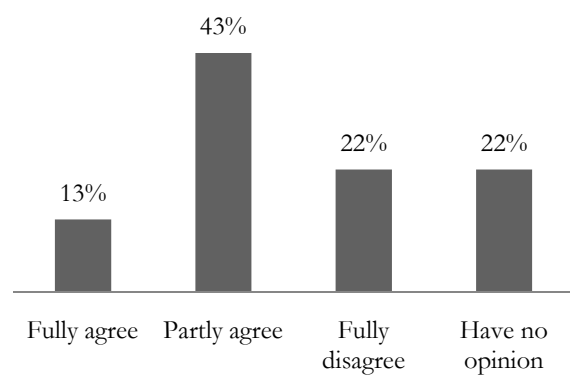


Figure 5: New technology are mostly motivated by lower costs.

Approximately 78 % agrees fully or partly that developers that build to sell take more risky decisions in the technical part than those that build, operate and maintain the buildings as rental housing (see figure 6). A reflection from the respondents is that the energy- and maintenance cost are more important if you are going to operate the property yourself and where the consequences of bad solutions can be more costly. The spread of opinions amongst the respondents concerning this statement is bigger in the public category than in the private one. Of the private respondents 80 % are positive to the statement where the rest 20 % doesn't have an opinion. Compared to the public where the figures are 17 % that doesn't agree and 6 % doesn't have an opinion.

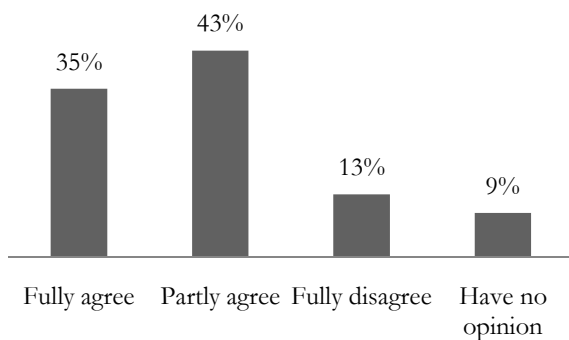


Figure 6: Developers for condominiums are taking higher risk when it comes to technical solutions than developers for residential houses with inhouse maintenance.

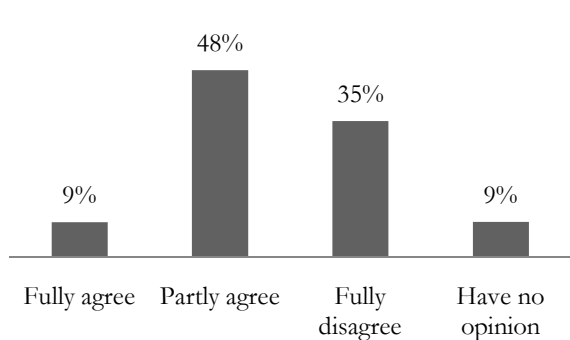


Figure 7: DBB contracts give a better control of project and the risk of failure and carelessness decrease.

The result in figure 7 above indicates that no clear conclusion could be drawn from the statement that DBB contracts gives better control of the construction but there are a small majority for those that at least agree partly. Interesting to notice is that 100 % of the private clients that participated in the survey partly agree that DBB contract gives a better control. Among the public sector respondents the view differed considerably: 44% agreed or partly agreed while 44% disagreed.

Comments to the statement were that the carelessness is as common as in other forms, but it is easier to control the technique and methods in DBB contracts. But they are flagging for that the key to better end products, decrease of construction failures and shortcoming are partnering.

Of the responses to the statement that it is the contractor who has most knowledge and thereby should have the full freedom of choosing technical solution and material, 56 % doesn't agree but on the other hand 44 % partly agree (figure 8). Notable is that 60 % of the private client are more positive and think that there is something in that statement that is right but the public client (61 %) doesn't agree at all.

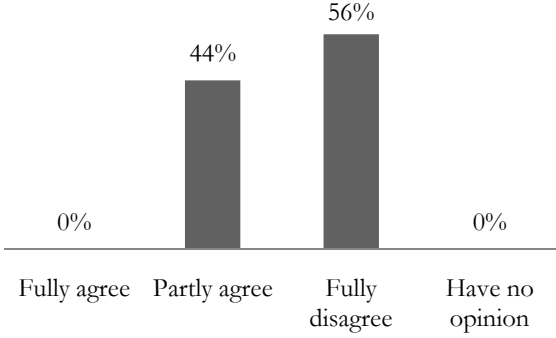


Figure 8: It is important to give the contractor considerable amount of freedom in the choices of technical solutions and material due to better knowledge.

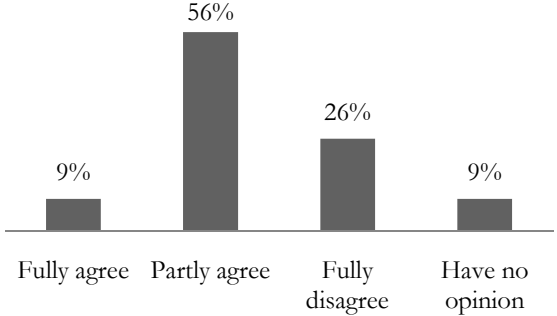


Figure 9: As a whole the client has better knowledge than the contractor of the suitability of different technical solutions.

Figure 9 reveals that to some extent there is a belief that the actor with best knowledge in the sector actually is the client, even though approximately 44% have the opinion that the contractors hold the best knowledge. As it was the clients that were asked it is interesting to see that so many still agreed that the contractor had the best knowledge. Differences in opinions on this question can however be related to how often they build.

The public clients think that it is partly true that functional demands is a good way of increasing the innovation in the sector and this partly contradicts the statement above concerning who has best knowledge in the sector. The private respondents are more careful in their responses and don't fully agree that this is the right way to go. All in all, approximately 70 % of the respondents to some extent agree that performances contract could be a good solution (Figure 10).

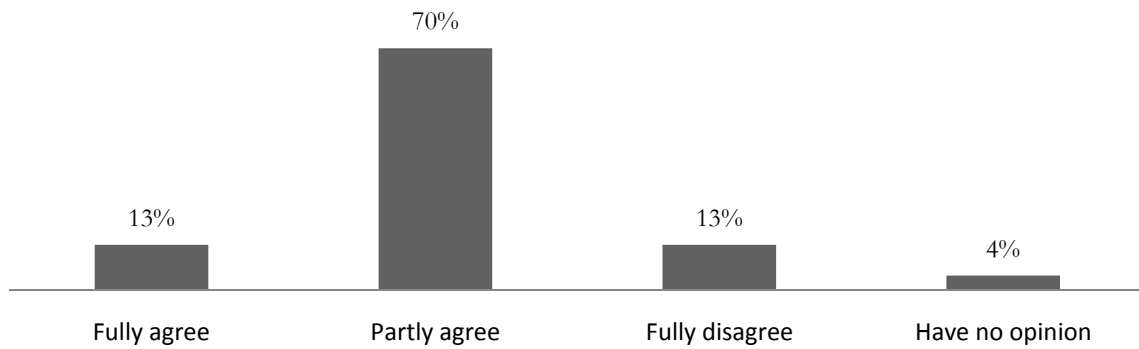


Figure 10: Contracts with functional demands is an important step towards an increase of innovation in the construction sector

6. CONCLUDING ANALYSIS

The construction sector have been criticised for a low level of innovation both in the construction process as well as concerning technical development, but also for taking life-cycle cost into account in a poor way. Bundling of design, construction and maintenance have been recommended as one solution in the infrastructural sector. In the multifamily housing sector there are also companies with different incentives where some property owners have a long-term perspective as they plan to operate it as rental housing, while other developers plan to sell the ready houses as condominiums. The study of infrastructure projects procured as integration of design, construction and operation/maintenance indicates that even though contractors have the possibility of using their own design, they seem to use already existing solutions and follow the norms and use established techniques to a very large extent. By following already accepted technical solutions the contractor can reduce the risk and easier verify performance and functions and avoid penalty for bad quality.

There are indications that developers who build housing to sell use cheaper and riskier technical solutions than those that have a long-term perspective of their ownership. The survey sent to private and municipality housing companies reveals that the private companies are more risk-averse and focus most on using established techniques. This can be related not only to the long-term perspective of their ownership but also a stronger financial perspective that differ from the municipality housing companies that are somewhat more involved in developing new techniques.

There is an overall positive view in the sector of implementing performance contract to increase the innovation in the sector and there is a trust in that the contractor has the knowledge and can take that responsibility. However, the survey reveals that still many sees the client as the actors with best knowledge of what is the best design from a long-term perspective.

Finally, there is no strong evidence that long-term contracts and bundling is a key to technical innovations in the sector, as the contractors seem to be very risk-averse. However, there are some support to the statement that more risks are taken when a housing developer sells to weak clients like households buying condominiums.

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APPENDIX 1

The questionnaire

The questionnaire was sent to 51 companies acting on the rental housing market, 19 private housing companies and 32 municipality housing companies. Of the 51 clients, 27 responded to the survey which means a response rate of 53 %.

Introduction

The aim of this survey is to collect information about choices of construction methods and material made by companies in the construction sector. The survey turns to companies, acting as builders in the production of houses. The survey consists of five sections and in total it will take 10 minutes to answer.

To obtain a result from the survey that could be relied on it is important that as many as possible answer it. For that reason we would be grateful if you fill in the questionnaire as soon as possible. Your answers will be kept confidential so no single answers will be identified.

Thank you for your participation!

Section 1: Basic information

1. Which sector does your company belong to?

	Public sector	Private sector
Number of respondents	20	7

2. How many employees do your company have?

	Public sector	Private sector	Response Totals
< 25	10%	50%	19%
25-100	45%	17%	39%
100-200	25%	17%	23%
>200	20%	17%	19%

If >200 approximately how many? (Open question)

3. Where in Sweden are you located?

	Public sector	Private sector	Response Totals
Cover the whole of Sweden	0%	0%	0%
In the big cities (Stockholm, Gothenburg, Malmö)	45%	67%	50%
In the south part of Sweden	20%	0%	15%
In the middle part of Sweden	25%	33%	27%
In the north part of Sweden	10%	0%	8%

4. Which position do you have in the company? (Open question)**5. For how long have you worked in the company?**

	Public sector	Private sector	Response Totals
Less than 2 years	0%	0%	0%
2-5 years	32%	50%	36%
5-10 years	26%	17%	24%
More than 10 years	42%	33%	40%

6. For how long have you worked within the sector?

	Public sector	Private sector	Response Totals
Less than 2 years	0%	0%	0%
2-5 years	0%	0%	0%
5-10 years	10%	0%	8%
More than 10 years	90%	100%	92%

Section 2: Earlier construction methods and material

In this section we want to look at the development of the sector, either from your own experience or what you have heard from colleagues in the sector/your company.

1. *If you look back on the constructions you have carried out the latest decade. Is there any construction/ construction technique that you have used but didn't work out as planned or that you regret that you have used?*

	Public sector	Private sector	Response Totals
Yes	56%	60%	57%
No	44%	40%	43%

2. *If you said yes in question 1, which technique/construction are you thinking of? (Open question)*

3. *If you look back on the constructions you have carried out the latest decade. Is there any construction material that you have used but didn't work out as planned or you regret that you have used?*

	Public sector	Private sector	Response Totals
Yes	56%	40%	52%
No	44%	60%	48%

4. *If you said yes in question 3, which material are you thinking of? (Open question)*

5. *If you look back on construction techniques/ material that OTHER companies in the sector have used during the latest 10 years, are there any techniques/ material they have used that you wouldn't think of using?*

	Public sector	Private sector	Response Totals
Yes	53%	40%	50%
No	47%	60%	50%

6. *If you said yes in question 5, which techniques/ material are you thinking of? (Open Question)*

7. *Do you have experience of the discussed rendered stud-wall technique?*

	Public sector	Private sector	Response Totals
Yes	50%	60%	52%
No	50%	40%	48%

8. *If yes in question 7, do you have had any problems with it?*

	Public sector	Private sector	Response Totals
Yes, big	9%	0%	7%
Yes, but rather limited	27%	0%	20%
No	64%	100%	73%

9. *If no in question 7, any special reasons for not using the technique? (Open question)*

Section 3: New construction methods and material

1. *Which/ which one of the following statements correspond to your company when it comes to introducing new construction techniques and material? (Multiple answers)*

	Public sector	Private sector	Response Totals
We are careful and wait until others have tested it so we know that it works.	39%	80%	48%
We want to contribute to the technical development and don't mind being the first on the market with new techniques and material.	39%	50%	30%
We make in-house tests on limited bases before we introduce new construction technique and materials.	17%	0%	13%
We foremost look at tests done by suppliers of goods and materials before we make any decisions.	39%	40%	39%

Other

If other, please specify. (Open question)

2. *People has in recent years advocated to build houses with wooden frames instead of concrete frames, is it something you have used?*

	Public sector	Private sector	Response Totals
Yes	33%	20%	30%
No, but we have thought about it	39%	40%	39%
No, it is not of immediate interest	28%	40%	30%

3. *If yes in question 2: What is your experience? (Open question)*

4. *If no in question 2: Is it for any particular reason? (Open question)*

Section 4: How do you look at the following statements?

1. *New construction techniques are motivated by lower costs.*

	Public sector	Private sector	Response Totals
Totally agree	17%	0%	13%
Partly agree	50%	20%	43%
Disagree	28%	0%	22%
No opinion	6%	80%	22%

2. *Companies that build with the intention to sell (e.g. condominiums) take more technical risks than companies that build houses for their own stock (e.g. rental houses).*

	Public sector	Private sector	Response Totals
Totally agree	33%	40%	35%
Partly agree	44%	40%	43%
Disagree	17%	0%	13%
No opinion	6%	20%	9%

3. *Design- bid- build contracts give better control of the project and the risk of bad quality and carelessness will decrease.*

	Public sector	Private sector	Response Totals
Totally agree	11%	0%	9%
Partly agree	33%	100%	48%
Disagree	44%	0%	35%
No opinion	11%	0%	9%

4. *It is important to give the contractor considerable freedom in the choice of technical solutions and material due to their better knowledge.*

	Public sector	Private sector	Response Totals
Totally agree	0%	0%	0%
Partly agree	39%	60%	44%
Disagree	61%	40%	56%
No opinion	0%	0%	0%

5. *Procurements methods with functional demands are an important step towards increasing innovation in the construction sector.*

	Public sector	Private sector	Response Totals
Totally agree	11%	20%	13%
Partly agree	78%	40%	70%
Disagree	6%	40%	13%
No opinion	6%	0%	4%

6. *The builder has in general a better knowledge than the contractor of different technical solutions suitability.*

	Public sector	Private sector	Response Totals
Totally agree	11%	0%	9%
Partly agree	50%	80%	56%
Disagree	28%	20%	26%
No opinion	11%	0%	9%