

TRANSFORMATION FROM DESIGN-BID-BUILD TO DESIGN-BUILD CONTRACTS IN ROAD CONSTRUCTION

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ABSTRACT

This article was triggered by a public client opting to change contracting strategy on a pre-designed 4-lane motorway project from design-bid-build to design-build contract. The goal for the client is to build roads cheaper and faster with the greatest possible economic benefits for society.

In the article, we ask: Which changes associated with the transition from a design-bid-build to a design-build contract can be identified in the contractual relationship between the public developer, contractor and subcontractors? The article focuses on changes in relation to constructability, construction time and costs, and discusses the issues of quality and customer value.

The study is theoretically related to the principal-agent theory and transaction cost theory, where the threat of opportunistic behaviour is central. This is also seen through the lens of the Lean Construction triangle, which focuses on the need for harmonisation between commercial element in the contract, organisation and production.

We analyse the case in relation to three propositions:

- Design-build offers incentives that result in better constructability than design-bid-build contracts.
- Design-build results in lower production costs and faster construction than design-bid-build contracts.
- Quality and customer value come under pressure in design-build contracts.

The first proposition seems to be confirmed by the empirical analysis. Production cost is, however, not the same as the price for the client. It is more uncertainty related to the third proposition. An important finding is that the developer's change in strategy seems to

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result in a radical change in working conditions for the consulting design and engineering companies, as well as to a great degree for the head contractor. A strong relationship between the contractor and consulting engineers is especially important to ensure success in terms of execution, and we find indications that alliances have been formed between the parties.

KEYWORDS

Contract form, constructability, cost, progress, customer value.

INTRODUCTION

In this article, we focus on the consequences of changing a contract model from design-bid-build to design-build on construction efficiency. Several quantitative studies have been done on the variations between design-bid-build and design-build, and several of the findings indicate that design-build produces more rapid construction time (Whittington 2012, Park and Kwak, 2017). The choice between design-bid-build and design-build is very much a trade-off between the construction time versus the uncertainty surrounding the cost aspect in each specific project.

The case for this article has been taken from road construction in Norway, where all public road construction has previously – and quite traditionally - been governed by the Norwegian Public Roads Administration (SVV). Next, Nye Veier (NV) (translation: “New Roads”) was created as a state-owned limited company established by the Norwegian government in 2016, having to enable more and faster construction of public roads with the available financial resources.

The article is only investigating the E18 Arendal – Tvedestrand road project, which is currently under construction⁵. The case comprises of two formerly connected stretches of road engineered by SVV as design-bid-build contracts, which are now combined as one design-build contract. The stretch of road in question is largely located on new terrain and encompasses a 23 km 4-lane motorway with several crossings on the route, including 27 bridges and more than 10 crossing points for wildlife. The contractual budget is approximately NOK 4 billion incl. VAT.

Based on contractual and structural change in responsibility and distribution of risk between central project participants, the overarching issue addressed in this article is: **Which changes can be identified in the transition from a fully engineered design-bid-build contract to a design-build contract?** We focus on changes in relation to constructability, construction time and costs in addition to discussing the issues of quality and customer value.

In the next sections, we first present the methodological choices made, thereafter the theoretical basis for analysing behavioural and contractual issues in business relationships. Subsequently, we propose a theoretical framework as the point of departure for our propositions. This is followed by an empirical analysis and conclusions made based on the propositions.

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METHOD

In this paper we are studying how the contract strategy has been switched from design-bid-build to design-build in one project. The unit of analysis is the change, as this type of alternation signifies that one set of incentives has been replaced by another set of incentives. Thus, our aim is to highlight what this means for the project's execution regarding the organization, the feasibility of construction, time, cost and quality. Since what we are dealing with here is a single project, the most obvious approach to choose is one form or another of the case study method. In this instance we first look to Sayer (1992) concerning theoretically informed case studies, then supplement this with Yin (2003), who distinguishes between analytical and statistical generalization in case studies. The term *analytical generalization* means that we conduct a test of our theory through engaging in discussion. The case study here focuses on questions associated with in-depth studies and questions in the form of 'why' and 'how'. We are in other words seeking explanations for our observations.

Next, we apply propositions to bridge theory and data. Each of these propositions is discussed in relation to our findings, where we see if the findings either disprove or confirm the propositions. In conclusion we return to the theory and evaluate whether or not it is fruitful for the study (abduction). The qualitative data are collected through conducting nine interviews, of which three are with the client, two with the main contractor (design management and production), two with project consultants (design management, BIM), one with the electro subcontractor and two with the construction subcontractor. Eldholm and Pedersen's master's thesis (2017) has supplemented this data collection.

THEORETICAL BASIS FOR ANALYSING BEHAVIOUR IN CONTRACTUAL RELATIONSHIPS

The major issue in the principal-agent theory is the contractual relationship between two or more parties, where one party, the agent, acts on behalf of another party, the principal (Jensen & Meckling, 1976). Different contractual mechanisms and incentives are used to govern the agent's behaviour and the possibility for opportunism (Eisenhardt, 1989). Misalignment of incentives and opportunistic behaviour are central issues in business relationships. Creating contracts with incentives that balance both risk and reward for both parties, may be a way to control the agent's behaviour in an appropriate direction for the principal. Contracts could include multiple dimensions of incentives, where the most effective balance, are of great importance in contract design (Kerkhove & Vanhoucke, 2015). However, a contract may only include the conditions that the principal is able to predict in advance, which in turn gives rise to an incomplete contract, and the agent room to act opportunistically after the contract is signed (Rindfleisch & Heide, 1997). The risk of opportunism is, to a large extent, the driving force behind contractual control mechanisms in business relationships (Williamson, 1985), and over decades vast amount of research has put these premises to the test.

In theory and practice, however, the mechanisms of governance and incentives to regulate inter-organizational behaviour do not find universal support. Several scholars

have criticised the theoretical grounds for opportunistic behaviour in business relationships. In his vast examination of contracts, Macneil (1977) distinguishes between transactional and relational contracts, where the latter puts more emphasis on trust rather than monitoring mechanisms. Following this, Granovetter (1985) argues that buyers and sellers in the market do not make their decisions based on price alone; rather, their experiences over time lead to relationships founded on trust. Moreover, Müller (2009) claims it is restricting to portray contractual relationships as pure transactions, and people as primarily opportunistic. Likewise, other scholars are emphasising that trust is not only a cost-cutting device, but channels for knowledge creation and a basis for interactive learning which trigger technological development and economic growth (e.g. Lundvall, 1992; Kalsaas, 2011, 2013).

We will analyse the research question through the lenses of *governance mechanism sand incentives* between the client and contractor in a large construction project, coupled with the lean triangle perspective for efficient construction.

THEORETICAL ANALYSIS AND PROPOSITIONS

The Lean Construction triangle (Ballard, 2012; Howell, 2011) is an approach to understanding framework conditions for efficient construction in terms of time, cost and quality, as well as customer value. The idea is that there should be a harmonisation between the commercial, organizational and production perspectives. In this case, the commercial side of the model refers specifically to NV's contracting strategy and agreement form. The essence of an agreement form can be the distribution of risk and responsibilities between the parties, clarification of which responsibilities belong to the developer and the contractor respectively, which responsibilities are shared, and which deliverables must form the outcome. Klakegg (2017) divides the agreement form into contract form, risk distribution, conflict resolution mechanisms and settlement form. Design-bid-build and design-build contracts are thus examples of contract forms that specifically define the other aspects of the agreement form, both design-bid-build and design-build contracts can be said primarily to be transactional (see e.g. MacNeil 1977).

The organisational side of the LC-triangle covers how actors in the value chain cooperate, including the developer and users, the main contractor, architects and engineers in design, subcontractors and suppliers, as well as external agents and stakeholder groups. How the actors collaborate has a significant influence on the flow, efficiency and value creation of production (Matthews & Howell, 2005). Collaboration can be characterised by limited trust and opportunistic behaviour/sub optimisation on the one hand, while on the other enabled by a large degree of trust and goodwill to find solutions to unforeseen difficulties that arise. However, the threat of 'moral hazard' and sub optimisation between the parties can still occur along the way.

In line with the premises of principal agent theory, contractual incentives may provide both opportunities and delimitations to promote efficiency in production, including design. From this perspective we can consider incentives as an underlying force of direction (structure), but contextual circumstances may prevent impact of incentives from

being observed in individual projects. If we examine many construction projects, however, we can expect the structures of the agreement forms/contracts to come through.

Based on the arguments above, we draw the following propositions:

- Proposition 1: Design-build offers incentives that result in better constructability than design-bid-build contracts.
- Proposition 2: Design-build results in lower production costs and faster construction than design-bid-build contracts.
- Proposition 3: Quality and customer value come under pressure in design-build contracts.

From the first proposition we argue that when the design-build contractor is responsible for both design and construction, they have incentives to adapt the design to their expertise and production equipment. In the case of design-bid-build contracts, the client is responsible for the detailed design, and there can be a time gap between the design and construction phases.

As the various entrepreneurs are different with respect to equipment and working methods it is impossible to design solutions that are equally constructible for everyone. In traditional design bid build contracts, clients aim to design road projects that are just sufficient for tendering a competition to build. Once an entrepreneur has been selected, designers are hired to complete follow-up engineering as well as work out detailed design. Without proper incentives, advisers may want to do the least amount of work possible before the tender competition, as they would at this point be working in accordance with a fixed rate contract, while follow-up work is reimbursed in accordance with hourly rates. In this sense advisers have incentives during the construction phase that coincide with those of the entrepreneur: The entrepreneur can demand to be paid extra through presenting change requests due to poorly executed drawings or those lacking key elements, while advisers earn extra by the same mechanism. Thus, the incentive scheme that follows a design bid build contract may hinder the execution of a project without hidden agendas. We can further assume a completely different dynamic between the contractor and design consultancy firm when the design phase is controlled and paid for by the contractor who will then be responsible for construction.

In proposition 2 we assume that costs and time is closely connected to the issue of constructability. Good constructability can be expected to yield lower costs and quicker production for the contractor, if they are otherwise operationally efficient and external risks are manageable. These savings in time and cost for the contractor may be shared with the developer and yield lower total costs of the project. However, in traditional design-build contracts, the supplier also factors in risk at a premium rate (cost) for the client. The literature does not confirm that design-build contracts become cheaper for the client, see for example Park and Kwak (2017). On the other hand, the literature confirms that design-build is favourable for rapid completion (op. cit.).

In addition to the constructability argument, the contractor is responsible in design-build for the lead time from start-up to handover and has the opportunity to optimise design and production processes to ensure rapid progress. In design-build contracts, design and construction take place simultaneously, rather than sequentially as in design-

bid-build contracts. This enables time crashing and may reduce the total completion time. In addition, we can expect less detailed design drawings if there is close interaction between the design and construction teams. Relatively long stretches of road in the same project provide the opportunity for many points of attack in the trace and utilisation of economies of scale for the contractor. Less rig cost adds to the time and cost benefits. For the contractor, this represents lowering the risks of fixed price contracts and progress delays.

In design-bid-build contracts, when the executing contractor is not responsible for the design documentation, there are good ‘opportunities’ for the contractor to find defects in the specified documentation, which may open for moral hazard, confer the previous theory. When price is highly emphasised for awarding the contract relative to other performance measures, we can particularly expect tactical pricing in order to win the contract, strong incentives for variation orders, and pressure for shirking on quality. Under these circumstances the conditions for opportunistic behaviour are thriving. The general notion of conflict and low productivity (e.g. Klakegg, 2017) in the construction industry underlines this.

From the above line of arguments, it follows that the quality and customer value can be under pressure in design-build contracts with a fixed price. Design-bid-build contractors may be more favourable for ensuring customer value as the developer retains control over the design phase. But to capitalize on this contractual arrangement, the developer needs major monitoring and control procedures to follow up the implementation phase, while at the same time ensuring disincentives towards poorer constructability and higher total costs. A contracting process that ensures early involvement of contractors will work towards strengthening the relationship (Svärd, 2016) and increasing constructability, while reducing costs. This is because contractor’s engineering knowledge can be utilized in the design, procurement and preparation of work documentation.

CONSTRUCTABILITY, COSTS, BUILD TIME AND QUALITY/CUSTOMER VALUE

PROPOSITION 1

The road works project was nearly done being designed as two design-bid-build enterprises when NV took over the project from the SVV. The respondents refer to several attempts to change the original project plans in order to not only make it constructible but also to eliminate unnecessary costs. For example, there was a level crossing where the line was raised by 14 meters, where the entrepreneur could reduce their soil-rock mass removal by 700,000 cubic meters, out of a total of 7 million cubic meters. In another example, the attempt to transform a tunnel into an intersection, which would have produced both lower construction costs as well as operating and maintenance costs, had to be abandoned. We are talking about changes that require zoning changes, where the municipality in which the initiative has started is the regulating authority. The head of the client’s project organisation states that “*we didn’t have a chance politically speaking, as so much negativity had been created even before the project got started*”.

The project was met with such a great deal of resistance to the change involving creating an intersection instead of the tunnel that the entire initiative was stopped. There was resistance from the zoning and state sector authorities associated with outdoor recreation and wildlife, as well as several private interest groups. There was no time for long regulatory processes. The individual case that probably created the greatest amount of negativity was that the main contractor had not included street lights in their original bid. Omitting street lights created a great deal of negative coverage in both the local and national media and was in the end not approved by the VD. Several people started to think that NV was going to build quickly, cheaply and badly, according to the head of the client's project organisation. Further, changes had been made to the wildlife underpass tunnels, something that is referred to as a "huge challenge" since there are no national guidelines pertaining to this matter. Additionally, several other minor changes were made which deviated from the original project plan. One informant from the design-build contractor states that 'we are good at some things, we choose solutions that are great for us and that work in relation to our production apparatus.' By example, reference was made to the formwork systems the company has at its disposal, and that such systems are not available off the shelf. Consequently, bridges are designed that are suited to these formwork systems. The informant also argued that 'when SVV designed the facility as a design-bid-build contract, they designed many different types of bridges and portals without any real purpose.' The design manager works hard to standardise to enable the reuse of formwork systems. He strives for a system with few variables to avoid having to use new materials and equipment and added that 'we can't afford it'.

The picture painted by the design-build contractor is confirmed by informants from the design side. However, in hindsight the design manager believes that 'we were too open and creative in relation to the opportunities at the beginning. We started off by taking on too many battles/changes.' Examples of this included increased fillings and shorter bridges. Bridges are highly costly.

The data gathered demonstrates that there is a close cooperation in the project between the main contractor and the designers. The design work was carried out by a major Norwegian consultancy firm, and they have all disciplines under one roof, also electrical specialists. The design-build contractor's design manager and two design assistants are based in the same location as the designers, and almost daily contact is reported for the discussion of solutions and priorities.

Details are moreover provided about a radically different working situation for the designers in the case of a design-build contractor, and in terms of simultaneous design and construction. One statement was that "*we have been controlled by SVV for 40-50 years*". In the past, "*we would deliver a main deliverable in transportation projects once every 6 months*," but that "*now we supply work documentation up to 2-3 times per day at times*." The findings also show that there are constant changes that need to be made to priorities based on the needs that arise on site, where geology and geotechnics are the major drivers of uncertainty for the project. The design-build contractor's design manager refers to coordination between the design and production sides, describing it as very important as "*production can suddenly say that we need to go into more detail on an area that we had envisaged*." This is something that has led to a lot of frustration amongst

designers who are suddenly informed that something they have worked hard on for a long period of time must be put on hold. Changes like this can occur because a job becomes more complex than expected and must be prioritised. One example was that the design-build contractor had underestimated the blasting process on one side of a bridge and had to change the direction of the work in order to buy time. According to the contractor's informant, willingness to change is very important in this approach to construction, cf. the following concerning the necessity for changes to attitude.

One change that results from this connection between design and construction is that the designers must deliver work documentation that is incomplete, which is something neither they nor the contractor is used to. This triggers a risk for the work documentation and 3D model being used for something it is not ready for. A system is used to manage degrees of maturity - the so-called model maturity index (MMI), which corresponds to Level of Development (LOD) system. The model can provide, for example, the work documentation for blasting/tracing the road, but not the basis for other road building tasks. The contractor describes this method as a 'top-down-method', which means that first they determine the blasting profile. In design-bid-build engineering, they would first strengthen the road using various types of layers before the blasting profile was determined. This change is an example of adapting to the head contractor's needs. Another point that emerges is that the contractor often does not require detailed designs for everything. The respondent from the contractor emphasises, in this regard, that for the road 'we need data to trace the road' while 'for construction of the road we have our own standardised solutions'.

Reference is made to the framework for design-build contracts which requires changes in attitude and that 'some still remain mostly occupied with finding design faults.' Engaging in self-criticism, the informant from the consultant states that they are often asked to recommend a solution from several options, and that "*on the consultancy side we find it easy to recommend the best solution, while the contractor is interested in something that is cheap and good enough*". The design-build contractor's design manager explains that communication with the designers has developed from being problematic to being "*much better*". Previously, we ended up with "*far too many questions from the experts*", and "*it may have been that our messages were not clear enough*". One challenge from the perspective of the design-build contractor is that "*the consultants work with their own tunnel vision and may not be aware of a number of other related issues*". Instead of preparing a complete solution that transpires not to be constructible, and having to start again, "*we try to correct the course while in progress prior to getting too far*". The informant adds that "*this is something we have to train at*". It is pointed out that to achieve this, it is very important to frequently involve the production apparatus. They provide input "*sometimes based solely on gut feeling, but it's often accurate*".

In comparison to design-bid-build contracts for roads, one design manager on the consultancy side claims on the basis of their own experiences that the SVV wanted good solutions, which are expensive, and that he - in his job - "*works to get the most work possible for my designers*". Furthermore, that "*this is completely the opposite to what happens in a design-build contract*". The informant makes the point that "*selling hours in design-build contracts is not the ruling factor,*" as "*time is too scarce*".

PROPOSITION 2

To manage the construction period in just 2 years and 9 months, “*you need a little bit of crazy*”, according to the design-build contractor’s design manager. He emphasised the need for “*very good progress monitoring*” and the ability to rapidly implement corrective measures in the event of deviations on critical tasks. It emerges from the interview with the design manager that excavation commenced one month after conclusion of the contract. A reflection from the same person is that “*it was too early - in the future we will need to have the plans ready before we begin to engineer*”. The consultant company began design work on behalf of the risk owned by the contractor during the tendering stage. The head of the consultants emphasises that it is “*technically straightforward to build roads on virgin territory, but since the construction project has to take place in a short window of time, it becomes complex*”. He adds that this is a “*way of clarifying solutions that we are not used to*”. The head contractor attacked the complexity in relation to the scope and time by dividing the projects into smaller control areas.

The subcontractor for constructions (bridges) has received the underlying design and drawings too late and responded by simultaneously working on more bridges than planned in order to follow the project’s schedule. At the time of the interview, 10 out of 26 bridges were being worked on. The informant pointed out the increased complexity involved with running 10 building sites at the same time. The informant had a feeling that they were only given priority within design after the road line had been taken care of.

A respondent from the head contractor places an emphasis on the importance of capturing ‘*everything*’ in the contract, which requires experience. This is due to the fact that the price of the same job, based on his experience, increases during the process, largely on the basis of follow on costs for other disciplines, but the contractors “*are also hucksters*”. For example, it was claimed that “*squeezing an activity into a very brief period of time, with lots of people and equipment, sees resource utilisation fall from the 90-100% mark to 60%. There might be a lot happening, but it isn't efficient*”. The contractor’s design manager says that “*we are happy to be tough when it comes to purchasing - it's survival tactics. My tactic has been to avoid going for the lowest price, but to aim for those in the middle layer*”. In the tendering phase, the head contractor allied itself with a regional concrete works contractor and an electrical contractor with its own design responsibility, in addition to the consultancy firm.

We have mentioned street lights. These were introduced in the work plan after the contract had been signed, and according to a respondent from the client, “*so we ended up paying more for street lights than what we would've done in a normal competitive situation*”, and he made the point that “*the longer you wait, the most it costs*”. The respondent explained this phenomenon as being a question of supply and demand, and that it is a “*relatively common occurrence in construction projects that additional work is something that entrepreneurs make a lot of money at*”. The client respondents pointed out that they felt it was important that contractors earned money, and that anything else would produce a poorer profession over time.

An informant from the head contractor who is closely connected with production claimed that it is difficult to say if design-bid is cheaper or more expensive than design-

bid-build, “*as the costs start running no matter what*”. His perspective was to utilise 130 large, expensive machines in two shifts: “*We’re very much on the ball, we don’t have time to sit around, we have to produce*”. Machinery costs is a central cost driver for the head contractor. Additionally, the respondent thinks that design-bid-build was easier to work with, because “*then the design work is finished*” and “*we can go directly to the client to find solutions to any problems that arise*”.

PROPOSITION 3

Respondents from the contractor feel confident that they are in control of the quality and refer to the fact that “*trust in the project is very high*”, and that the head contractor “*plays with very open cards*”. A development has taken place in the project in the sense that the client had thought that they were not to be out on the building site hardly at all in order to have “*full control over what happens when and where*”. They are referring in this regard to the fact that “*there is, in spite of everything else, a huge investment of 4 billion*” (NOK). The client’s staff inspects both the entrepreneur’s quality systems and performs direct daily checks, and an informant claims that their experience is that it is not enough to inspect indirectly, that despite everything there are 800 men employed by the head contractor who are working on the construction site, and who might have different approaches to assuring quality. The head of the client’s project organisation states that “*I am very happy to have my inspectors*”.

The execution of government road works projects in Norway is strictly regulated through among other things a system of handbooks that describe this execution in detail. A distinction is made between ‘must’ and ‘should’ requirements. Deviations from ‘must requirements’ are to be approved by the VD, while the regional SVV-organisations processes ‘should requirements’. This implies that even if it is a design-build contract emphasizing functional description, it is also a system of quality assurance requirements that practitioners must base their projects on.

The data shows that experiences with the handbooks vary slightly. According to the head contractor’s design manager, they have “*spent thousands of hours on understanding the handbooks, which are often inconsistent*”. Furthermore, the informant states that “*if we are to aim to build cheaper and better, something has to be done about the regulations*”.

Another aspect connected to progress and costs is, according to the informant from the head contractor, that NV requires a reporting regime in the project that is equivalent to what would be required on a design-bid-build contract.

CONCLUSION

The quality data show that great efforts have been made in the project through increasing construct ability and simplifying the project in a way that we can easily relate to the transfer to design-build. One obstacle to being able to move further in this direction is existing zoning plans and external forces working against changes. Moreover, we see from the data that road construction using a design-build contract provides a radically different working methodology in terms of implementation than is found in design-bid-

build contracts. Thus far, the data shows that the close relationship between the design-build contractor and the designers appears to be very much central to success. All in all, proposition number 1 concerning constructability appear to be verified.

With respect to the aspect regarding rapid progress in proposition 2, we have found indications that most likely concur, including improved constructability from proposition 1, working in several parallel places, simultaneous engineering and construction conducted by the entrepreneur, utilisation of large scale advantages with regard to rigs and operations. There are moreover indications of good collaboration between the client organisation and head contractor, who are pulling in the same direction.

The indications regarding progress may also be connected with reduced costs in design and production. The design work must take place more quickly and seems to have with a less detailed design for certain work tasks. This indicates relatively less resources for design, and along with the other factors, design-build seems to produce lower production costs, given that the head contractor manages to optimise his demanding logistics with good flow and resource utilisation. Design-build also has a regime of change requests that can contribute to pulling costs upward for the client. On top of this, there is figuring out the risk costs. Altogether the data indicate lower production cost, but that is not equal to lower price for the client. A more secure analysis would require including more quantitative data.

In relation to proposition number 3 concerning the fact that design-build contracts put pressure on quality and customer value, we have less data to verify, but it has been confirmed to some extent. However, this primarily stems from theoretical grounds that strong focus on progress and costs may lead to reductions in quality. The data shows that there is a focus on construction to a good enough standard, rather than the best possible. It appears that the VD's handbooks are significant for ensuring a minimum standard, even if they can simultaneously be a source of irritation for practitioners.

The theory concerning incentives is confirmed in relation to expected changes in behaviour due to the transition from design-bid-build contracts to design-build contracts (proposition 1), which means we can assert that this is an appropriate theory for the analysis of such a phenomenon.

Further research on how contractual strategies may change incentives for collaboration and efficiency in construction is planned to include additional investigation of multiple partners in the construction value chain, through both quantitative and qualitative research approach.

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