Comparative Analysis of Mega Road Construction Projects in Term of Innovation

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Abstract *Purpose* This paper examines, using critical realism, the causes and mechanisms of innovation in three civil road construction projects. Its focus is to examine how value can be created within the design process through innovation. Emphasis is placed on Best Value Procurement (BVP) as a procurement strategy where the preferred contractor is considered the expert, as it is the first case of its use in Norwegian road construction projects. Data was collected through surveys and interviews. Findings indicate that procurement using early involvement is innovative in the design process yet must be adapted, to allow for early planning of innovative ideas that help, to foster innovative solutions. However, there are also some contributing causes towards a lack of innovation due to the strategic choices within the projects, such as how the project will be delivered in terms of, the commercial incentives within the contract.

Keywords BVP · Incentives · Innovation · Mechanisms · Value creation

1 Introduction

The construction and building industry are changing through many initiatives by governmental departments in Norway. Its focus is to strengthen the public sectors ability to implement change and to become more efficient. As a result, Difi (a Norwegian state department with responsibility for public procurement, management and digitisation of the public sector) has invested in a method called Best Value Procurement (BVP) to bring a significant improvement to public sector procurement. BVP is a method developed by Dean Kashiwagi at Arizona State University in 1994 and was first implemented in 2005 by the Directorate for public works and water management in the Netherlands, called rijkswaterstaat, tested and adopted BVP in 2008

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(Storteboom et al. 2017). BVP has five phases: preparation, tender, evaluation, pre-award/clarification, and execution (Kashiwagi 2011; Van de Rijt and Santema 2012). A six-page document and interviews of key personnel are performed in the evaluation stage examining past performance information, project capability, highlighted client's risks in the project and additional values that can contribute to the project goals. The pre-award/clarification stage is where the contractor can concretely make it clear the scope of the work for the project including the expected timetable, important milestones, risk assessment plan and define how they will, satisfy and exceed all the requirements of the contract. If the contractor's offer is accepted, then a contract is signed, however, if the contractor's offer is rejected, then the procurement process will starts over again. In 2016 Difi carried out an initiative to pilot ten BVP projects in Norway in order to highlight the strengths and weaknesses in the method.

A state-owned limited liability company under the Ministry of Transport and Communications called Nye Veier (NV) (translation: New Roads AS), decided to use BVP as their main procurement strategy and two projects, E18 Rugtvedt-Dørdal and E6 Arnkvern-Moelv, were pilots projects for Difi. NV were tasked to construct, operate and maintain the main roads in Norway. Their main goals were to ensure faster construction and an equal quality standard of 4-lane motorways with the aim of transforming the construction industry of which innovation is a part. In addition, societal value is very important in their business model. This reform from the government resulted in the existing, Norwegian governmental agency, responsible for the public roads in Norway, Statens Vegvesen (SVV) (translation: State Highway Authority), giving a part of its portfolio of road construction projects, to NV. SVV intended to build these projects using a Design-Bid-Build (DBB) execution approach. However, NV would instead use a Design-Build (DB) strategy, in other words, a contract whereby the supplier is responsible for integrated detailed design and construction. NV was motivated by their change to the DB-strategy by experiences from Sweden which road authorities build cheaper roads by using DB, according to an unpublished consultant report.

NV is responsible for operation and maintenance of their road sections. Public procurement in Norway must adhere to EU-regulations stipulating open and fair competition.

Also, the construction industry has over time been characterised as having low levels of innovation (Koskela and Vrijhoef 2000). The 2017 Norwegian bibliometric data for the construction industry shows that Research and Development (R&D) investment in innovation by companies is low. The problem is not that there is no innovation; the statistics clearly show increased rates of R&D from 30.43 million USD in 2016 to 39.81 million USD in 2017, a rise of 30.8%. The fact is the industry is spending more money than it ever had compared to 2007; however, this figure is significantly smaller compared to other sectors. Innovation activity in the construction industry from 2014–2016 in Norway, measured by the number of innovative or innovation projects, have been below average, compared to all industries. However, the fact remains that innovation in the construction industry, regardless of how it is measured, is being adopted and being created regardless of its comparatively low

level compared to other industries (SSB 2019). The goal of this research is to examine if BVP is an enabler for innovation in NV's road construction projects.

2 Theoretical Framework

Innovation originated in the late middle ages where the English language began to replace the Latin verb "innovare" with innovate or innovation: meaning "the action or process of innovating" or as "a new method, idea, product". In line with the Latin definition, the perspective of Tidd et al. (2005) is that innovation is a process, position and a paradigm, all involving a change in what an organisation produces.

However, the term innovation has different meanings depending on a person's perspective. For example, the Norwegian Central Statistics Bureau (SSB), define four types of innovation: Product innovation where a new or significantly improved good or service is introduced; process innovation—the implementation of an improved production or delivery method; organisational innovation, similar to process innovation—the implementation of a new organisational method in the firm's business practices, workplace or organization; and, marketing innovation where a new marketing method is introduced to change product design, placement, promotion or pricing. Whereas Slaughter (1998), viewed innovation on a scale, at one end, incremental innovation consisting of small changes to a specific element or component. Next modular innovation where it has limited impact on other components or systems, then there is architectural innovation which has a small change within a concept or components. Afterwards comes systems innovation being a link between multiple innovations which are integrated together requiring significant changes to components and systems. Finally, radical innovation, which comprises of a breakthrough in science or technology causes major changes to the industry.

Schumpeter in 1942, regarded innovation as discontinuities, either rendering obsolete competence or building on existing know-how through technology advancements. He suggested a distinction between invention (generating new ideas) and innovation (applying new ideas) (Tidd et al. 2005; Winch 1998). Von Stamm (2008) definition of innovation, bears a resemblance to Schumpeter, as he describes innovation as creativity plus successful implementation, further stating that often, innovation requires creativity (coming up with ideas) plus putting those ideas into practice (idea, selection development commercialisation and creativity). Christiansen (1997) in Von Stamm (2008), seem to build on Schumpeter's work, states that innovation can be defined as a technology, product or process, that sneaks up on a business and impends to displace it.

As mentioned earlier, incremental and radical innovations are not the only form of innovation; innovation models have tried to capture the broader perspective. For example, Miller et al. (1995) argue that certain models exist of industries pertaining to complex system industries, which as a result changes their dynamics of innovation and affects the different types of actors in the innovation network especially their distinctive roles in the innovation process (actor-system network). The network of

actors play an important role in understanding who is the key initiators of innovation in a project; however, Eric Von Hippel in Von Stamm (2008) argues that users, are also an important source of innovation, and are perhaps the ones who have the main stimulus. Ive in 1996 argued that "construction innovation depends upon the coincidence of the means, motive and opportunity to innovate" (Winch 1998, p. 274). Projects participants (trade contractors) often have limited incentive to be innovative when they are selected in a competitive environment where price is an important factor in order to achieve the contract (Winch 1998). In 1993, Slaughter had argued that innovation occurred, often by the people working on site, which was (and still is) not always recognisable. Innovations take time and money and the pressures during construction due to these factors often result in the production of an "adequate" solution so that construction progress could continue, instead of the "best" solution. Winch (1998, p. 274) points out that "If incentive structures did not favour innovation, then innovation is unlikely to take place" (p. 274). The only way to encourage innovation was to incentivise and motivate actors in a direction that favours innovation.

On the other hand, focusing more on managers, who were the innovators, had the problem of turning these innovative "ideas into good currency". How to incentivise and motivate agents (contracted for work) is a challenge, according to the principal-agent theory (Eisenhardt 1989). For example, Information may be misleading, between the owner and the agent before and after contract signing, for opportunistic gain. However, Buckley and Enderwick (1989) point out that that from a contractor's perspective it is his "desire to find a competitive price that is consistent with an acceptable rate of return given the risk and inherent uncertainties in the construction process". Winch (1998) suggested that construction is made up of a complex system which requires management of four processes, in order for successful innovation to occur: the firm level consisting of two processes—both an adoption and implementation dynamic (the ability to adopt new ideas)—then at the project level, two processes, where problem-solving and a learning dynamic occur (where there is the ability to learn and re-apply this learning to future projects, in a qualified form). The two forms are stimulated by a learning organisation. This is also supported by Bygballe and Ingemansson (2014), who argues that "explorative and exploitative type of learning, is a prerequisite of the innovation process." Von Stamm (2008) outlook on innovation suggests that even if an organisation tries to be innovative, they need to allow for creativity, an example of this can be seen in Kalsaas (2013) which addresses collaborative innovation regarding drilling performance in the oil industry. Creativity can be stimulated through training and creation of the right environment; however, environmental components can also sometimes hinder creativity. Encouragement of information flow, freedom to conduct one's work, and having available resources—all these can foster creativity. On the other hand, workloads might be positive, in providing creative challenges, but might also produce negative pressures leading to a blinkered outlook. Furthermore, organisational culture, such as conservatism and internal problems tend to be also negative elements influencing the creative environment.

In the end, creativity relies a lot on intrinsic motivation, which can be inspired but not enforced. If an organisation wants to be innovative, they must employ people to think and behave differently, which requires time. Correspondingly Nam and Tatum (1997), argue that innovation will be slow unless there are innovate leaders in projects, denoted "champions". In construction, the role of the champion tends to be split between the principal constructor and the architect/engineer, whose roles are the fulcrum for innovation. While this may be true, Kalsaas (2013) suggests that this role arises from the customer-supplier interaction. Bowley, on the other hand, suggests that innovation can and is often found by "ersatz"-substitution when all other solutions are unavailable. Whereas Bonke suggests that even though one is innovative, it can be stifled either through the exploitation trap (for example locked into a particular technology) or through the exploration trap (whereby technology is reinvented in a circular rather than a progressive manner) (Winch 1998). Research shows that early involvement has various impacts on the design and construction in a project. Examples can be seen in Song, Mohamed, and AbouRizk (2009), who examined the impact of early involvement in design on the construction schedule performance and Wondimu et al. (2016) who studied early contractor involvement (ECI) in public procurement projects and its effect on consistent product and process designing.

3 Analytical Model

Innovation can have a wide variety of meanings; however, in this paper, innovation is defined from the theory as product, process and organisational innovation. We have created an analytical model in Table 1 which will be applied to analyse the research question: is BVP an enabler for innovation? Five variables were chosen which address contracting, fixed price, time compression, early involvement and the client goals on innovation. The client's contracting strategy is to have strong impact on innovation as it is here that the commercial incentives for the parties are decided. In summary the analytical model, see Table 1, shows that there are excellent conditions for innovation if commercial incentives are aligned, the contractors are paid for creating value, time is available for creativity, learning and innovation, contractors are involved early; and that the client has clear goals on innovation which are proactively followed up.

In procurement during the bidding phase, the providers are open to all types of innovation due to the relatively strong incentive that arises from the possibility of being awarded a contract. It is the contract that is the mechanism that drives all participants to look for opportunities to innovate. An example is the bidder suggests innovations for the project. If a signed contract has a fixed price, then it has been used to shift the risks from the owner to the contractor. When the contract is signed it gives a limited incentive to focus on product innovation because the focus has now shifted to lowering costs in order to make as much profit as possible. However, this mechanism to potentially lower costs means that it gives a relatively strong incentive

Table 1 Relationship between type of innovation, variables and mechanisms in projects

Innovation	Variables				
	Bidding phase contracting	Fixed price	Time compression	Early involvement	Client goal innovation
Product	Relative strong (contract—commercial incentives)	Limited (potential lower costs)	Limited (time pressure)	Relative strong (joint problem solving)	Relative strong (focus, reporting)
Process	Relative strong (contract—commercial incentives)	Relative strong (potential lower costs)	Relative strong (time pressure)	Relative strong (joint problem solving)	Relative strong (focus, reporting)
Organisation	Relative strong (contract—commercial incentives)	Relative strong (potential lower costs)	Relative strong (time pressure)	Relative strong (collaboration)	Relative strong (focus, reporting)

to seek out, both process and organisational innovation, in order to become as efficient as possible in the project. An example could be using Lean methodology.

A contractual delivery date can limit the amount of time in a project, then the incentive to innovate is limited because those delivering the project have no time for product innovation and project modifications require approval. However, a pressured timeframe is a mechanism that also gives a relatively strong incentive to seek out both process and organisational innovation in order to organise and run the projects as efficiently as possible. Early involvement into the design process is another variable in a project, where there is a relative strong incentive to focus on both product and process innovation to solve problems in order to achieve improved constructability. The mechanism here is joint problem solving, innovations to help solve problems that would be encountered later in the project. There is also a relatively strong incentive to pursue organisational innovations by collaboration to increase organizational effectiveness.

The client is a variable that plays a vital role in innovation. Firstly, if they set a goal in the project to be innovative, this is expected to create a relatively strong incentive, especially in the bidding process, to potential participants in execution to focus on pursuing all types of innovation. However, this incentive decreases when the contract is signed and becomes less effective when combined with fixed price remuneration and time compression. Secondly, if the client, after the contract is signed, pushes for innovation in the project this strengthens the message for project participants to be innovative. The mechanism for both instances is the level of proactiveness from the client, which can either create or reinforce the incentive for innovation in the project.

4 Method

The research reported on in this paper is based on a mix-methods approach leaning to Yin's (1994) approach and critical realism from Sayer (1992), in theoretically informed case studies. Data was collected from three master student projects.[1] A total of 136 survey respondents responded from the three projects, where 57, 49 and 30 responses were collected from case studies 1, 2 and 3, respectively. Also, 29 semi-structured interviews were conducted within the 3 projects where 9, 11 and 9 participated from case studies 1, 2 and 3, respectively. Interview data was analysed using a method for analysing qualitative research called the framework analysis method, to find the themes for analysis (Gale et al. 2013). The respondents in the study included respondents from the Owner, Main Contractor, Design Consultants and Sub-contracted; Engineering, Construction and Electrical consultants' firms.

5 The Cases

Case study 1 concerns the E18 Tvedestrand connection to Arendal route based in the southern part of Norway. This project started as two projects, which were merged into one project to allow the contractor to utilise the 10 million cubic meters of overburden collected throughout the different stages of the road construction, see also (Kalsaas et al. 2018). The awarding criterion is shown in Table 2. This was NV first, and largest DB contract which was completed July 2019 (3 months ahead of contracted schedule).

Case study 2 concerns the E18 Rugtvedt-Dørdal project located in the south-eastern part of Norway. The project used the BVP procurement process and had an optional maintenance contract which could be awarded in order to compensate for the negative aspects that can occur in a DB by incentivizing the main contractor to think about quality and customer value (Kalsaas et al. 2018). The project is due to be completed in December 2019.

Case study 3 concerns the E6 Arnkvern-Moelv project, a 24 km stretch of road based in the eastern part of Norway. The project used the BVP procurement process and had the possible awarding of an optional operational and maintenance contract, for 20 years. The project is due to be completed in June 2020. Data was collected at different times in the projects with Case 3's data being collected when participants had the least experience working together, case 2 had more experience than case 3 whereas Case 1 data was collected when participants had the longest working experience together, in relation to all cases.

[1] Andersen and Vee (2018), Engelien and Ronæs (2018) and unpublished work from Willemsen, Axel (2018).

Table 2 Summarised overview of the three case studies

	Case study 1 E18 Tvedestrand-Arendal	Case study 2 E18 Rugtvedt-Dørdal	Case study 3 E6 Arnkvern-Moelv
Procurement procedure	Traditional DB contract. process with negotiations	BVP	BVP
Awarding criteria	Organisation 5% HSE 2% Implementation 5% Technical solution 2% Environmental consideration 3% Price 83%	Performance justification 25% Clients risk 15% Additional values 10% Interviews 25% Price 25%	Performance justification 25% Clients risk 15% Additional values 10% Interviews 25% Price 25%
Contract value (ex VAT)	3.076 billion (NOK) or 310 million (EUR)	1.8 billion (NOK) or 186 million (EUR)	2.15 billion (NOK) or 222 million (EUR)
Compensation	DB fixed price	DB fixed price	DB fixed price
Is there an optional contract	No	Yes, 20 maintenance years	Yes, operational and maintenance 20 years
Deliverable	25 km four-lane highway, 27 bridges, 4 twin bored tunnels, 2 road junctions, 9 culverts	16.5 km four-lane highway, several crossing and 27 bridges	24 km four-lane highway, 2 railway bridges, two short tunnels
Area plan	Inherited two finished plans	Inherited finished plan	Inherited finished plan

6 Findings and Discussion

The theory and analytical model presented above will provide the framework for the discussion of the empirical evidence. Findings from the surveys, see Table 3, indicated positive attitudes to innovation in all three mega-project case studies. The results show that Case 2, E18 Rugtvedt-Dørdal, were more positive to their project being characterised by new solutions and innovation compared to the other cases. Highest scores were found in case 2 E18 Rugtvedt-Dørdal compared with the lowest scores in case study 3 E6 Arnvern-Moelv.

It is interesting to notify from Table 3 that the traditional procured DB-project (case 1) received a better score than one the BVP projects (case 3) regarding innovation. Below we discuss briefly findings from the interviews case by case.

Case 1

Findings, Case study 1 E18 Tvedestrand-Arendal match expectations from the theory. The delivery model was a Design-Build (DB), and the contractor were procured using traditional procurement. However, as this is a contract where the main contractor is set to deliver the project for a fixed sum, their incentive to innovate was limited

Table 3 Attitudes from the survey

	Case study 1 E18 Tvedestrand-Arendal (%)	Case study 2 E18 Rugtvedt-Dørdal (%)	Case study 3 E6 Arnkvern-Moelv (%)
Completely agree	21	23	20
Somewhat agree	47	55	36
Neutral—no difference from previous projects	24	16	30
Somewhat disagree	4	2	7
Completely disagree	2	0	7
No opinion	2	4	0

in line with the analytical model in Table 1. When looking at the overall responses, participants had different interpretations of what innovation was in the project. Some stated that there was no innovation, while others agreed that, the project had product innovation through the use of an initiative of a model-based approval process using BIM, to remove paper drawing from the construction process; this is perhaps not that new to the industry, but again new to this project type.

There were some that stated that there was process and organisational innovation through the use of a DB instead of a DBB, nevertheless, some of these respondents, especially from the main contractor and consultants, discussed how the execution model DB reduces the time to evaluate solutions due to simultaneous design and construction. This is also consistent with the analytical model in Table 1 that time compression gives limited incentive for product innovation; often resulting is an adequate solution instead of the best possible solution. However, time pressure is also a mechanism that gives a relative strong incentive for process innovation. Yet from the owner's perspective, the project was a reworked areal design, and it was down to the main contractor, to be innovative.

Case 2

The findings, from Case 2, E18 Rugtvedt-Dørdal indicates that the project had an initiative planned to increase quality considerations, through the possible awarding of an operation and maintenance contract to the main contractor. The delivery model was a Design-Build (DB) and procurement of project contractor was done using BVP method, the first of its kind in Norway. The findings indicate that some stated that there was no innovation in the project, while a vast majority were extremely favourable to the project being characterised by innovation. Product innovations were stated as being through BIM, and Virtual reality whereas process and organizational innovation were through new ways of working such as DB, instead of DBB, early involvement from the main contractor and designers with the municipality on detailed area planning and the use of BVP.

Positive attitudes to innovation were attributed to the main contractor and designers use of time within the BVP procurement process. The main contractor's assumption that they would win the contract early since they were in the concretisation phase allowed them to start the project early and gave them extra time in planning of the project. This would be a plausible explanation as to the lack of references to limited time compared to the other case studies; however, the time pressure, together with the early start gave the participants a relatively strong incentive to collaborate and solve problems in line with the analytical model in Table 1. However, the consultant and designer organisations had prior experience of area planning and were able to reuse this knowledge again in this project.

The owner had a set goal for innovation and is mentioned as pushing for innovative thinking only at a certain time in the project. Examples were given by the designers and main contractor of their plight towards innovative ideas in dealing with lighting the main highways. These findings are, in line with the analytical model that strong incentives, for product and process innovation, occur through early involvement and the client's goal. However, since there was still time compression, with the use of DB, and a fixed price contract, these limit the amount of time to be innovative. Also, the owner's goal can be assumed, in the bidding phase before contract signing, to give a relatively strong incentive for innovation; however, after contract signing coupled with the use of fixed price, this incentive would decline. The incentive could be even stronger if bidders were required to answer how they intended to handle innovation in the project using the two-page document for additional values listed in the BVP process. This would give a relatively strong focus on innovation but also some form of measurement in relation to the client's goal. The awarding of the optional maintenance contract is an important incentive that looks to increase quality in the project; however, this incentive, if coupled with other reinforcing incentives, could give an even stronger incentive for product innovations. Nonetheless, there were those who experienced a lack of innovation in the project, because of the amount of regulations and the very detailed requirements present in the handbooks in the project.

Case 3

The findings from Case 3 E6 Arnkvern-Moelv, are from a project using Design-Build (DB) and the BVP method. Also, the owner had an offer of an optional 20-year operational and maintenance contract. The results showed that there was a mix of attitudes to innovation in the project. The project claimed to be innovative through, engineering and automation, BIM, environmental awards and the reuse of detailed plans. There were those who experienced a lack of innovation because of the very detailed requirements present in the handbooks and the difficulty getting in touch with decision makers in the project. There was also a conflict between the consultants and the main contractor because of claimed lack of proactiveness from the main contractor's part in the project, which resulted in the design managers for both parties being replaced. Discussions also revealed that time pressure, from the DB process, and the fixed price contract were the main causes that limited innovation in this project.

According to data, time pressure led to well-known solutions to being chosen in the project. The owner, similar to case 2, believed that the main contractor was responsible for innovation in the project, since it was a DB contract.

7 Conclusion

The paper analyses if BVP is a driver for innovation in three of NV's mega road projects. The quantitative and qualitative analysis found inconclusive evidence to suggest that best value as a procurement strategy was a driver for innovation in two of the case studies. Use of the analytical model showed that in cases 1 and 3, there were limited incentives to innovative, even though case 1 used traditional procurement and case 3 used BVP. Both cases were based on the project's strategy to use DB, a fixed price contract and the client assuming a lesser role in innovating. In addition, case 3 did have internal conflicts between the main contractor and designers, which is a contextual issue. However, in case 2 the project was more innovative due to an early start using the BVP method, initially caused by the time pressure in the project however innovative actions were based on prior experience (innovative leaders) and the owner pushing more for innovation in the project. It could be argued that BVP was an enabler.

There was a broad plan from owner to be innovative however there was no conscious plan as the project's delivery strategy give different incentives which both hindered and promoted innovation in the projects. It was also clear that the owner regards the main contractor as the main innovator in the projects, not themselves. Findings also identified contextual conditions in all three case studies which influenced the levels of innovation in the projects such as the number of mandatory handbooks, regulatory regulations and the ease in obtaining approval from decision makers.

Innovation can be improved, within a project's delivery model, such as sharing risk and reward by extending it to the main contractor and designers so that those in a position to innovate are rewarded for taking such risks (Kalsaas et al. 2018). Procurement is another example which can include innovation, e.g. BVP awarding criteria, the two-page criteria on additional values, could be adapted so that bidders were required to answer how they intended to handle innovation in the project. Innovation can be improved, not just based on a projects delivery model but by being aware of other contextual factors in projects such as having enough time, money, participant who can share information and work together as well as learning organisations.

The findings from the case studies were consistent, reliable and repeatable while external validity was analytically generalizable based on the analytical model, which provided an explanatory framework with wide applicability, not just to NV but to others who are interested in innovation in complex projects. In addition, the analytical model created identified the relationships between the types of innovation, variables and mechanisms in projects. However, innovative leaders might be a factor which is missing from the analytical model.

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