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DO ACTORS' INCENTIVES OBSTRUCT SECTOR-WIDE LONG-TERM PRODUCTIVITY IN THE DESIGN AND PRODUCTION OF BRIDGES IN SWEDEN?

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Abstract. An increase in productivity is necessary to reduce economic costs in bridge projects. Previous research indicates that construction productivity has decreased since the 1960s. A quantitative study was performed to find out how the incentives of the three major actors (client, contractor, and design engineer) could be obstacles to long-term productivity in the Swedish bridge construction industry. The study was performed as a self-completed questionnaire and received 151 responses. The results show that the contractors' employees find profit in a single project more important than the company's profit over time. Thus, the project´s incentives obstruct innovation and standardization, which could benefit future projects and thereby increase long-term productivity and the company's profit over time. In contrast to contractors, design engineers and clients value company profit more than profit in a single project, and they value the quality of delivered products as the most important factor for increased long-term productivity.

Keywords: productivity, incentives, obstacles, early contractor involvement, design-build, design-bid-build.

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1. Introduction

Globally, the construction industry is responsible for around 37% of the total CO2-equivalent emissions (United Nations Environment Programme, 2022). The construction industry is also an important contributor to the economy in most countries (Hasan et al., 2018), and globally, it accounts for 13% of the world's GDP (Barbosa et al., 2017).

At the same time, the lack of productivity increase is a well-known fact; research indicates that productivity has decreased since the 1960s (AIA, 2007; Laufer & Borcherding, 1981; Wodalski et al., 2011). A case study in Singapore shows that the annual growth in construction productivity was negative in 2 of 7 years, and it was below the growth of the total economy in 4 of 7 years (Ofori et al., 2020). Numerous studies, at different locations, have come to the same conclusions (Abdel-Wahab & Vogl, 2011; Barbosa et al., 2017; Delarue et al., 2021; Hasan et al., 2018; Ofori et al., 2020; Seadon & Tookey, 2019; Slaughter, 1998; Sveikauskas et al., 2016). Whether there has been a decrease or lack of increase in productivity is hard to tell (Sveikauskas et al., 2016). However, even though much of the existing literature states that productivity is low in the construction industry, there are studies that indicate an increase in productivity (Ahmad et al., 2020; Allmon et al., 2000).

The bridge construction industry is not an exception to the sector-wide low productivity; several studies point out a lack of productivity related to bridge construction (Harryson, 2008; Larsson, 2012; Simonsson, 2011). An example by Wodalski et al. (2011) showed that for rebar installations, 32% of the time was spent on value-added activities while 29% was pure waste.

Performing research on productivity is challenging; researchers are often interested in measuring productivity for a specific task, while the contractor may be more interested in the productivity of the project (Thomas et al., 1990). And there are numerous aspects that influence productivity increase.

One main aspect is altered regulations and requirements over time; these can significantly impact productivity negatively, according to (Abdel-Wahab & Vogl, 2011; Sveikauskas et al., 2016). Changes in regulations often imply an increase in material usage, which also has implications for the time needed to construct a bridge and, thereby, impacts long-term productivity (Ekström et al., 2014; Nilsson et al., 2021; Sveikauskas et al., 2016). This alteration may imply difficulties in measuring productivity over a longer period of time. Closely related to altered regulations is the increased demand for quality, which has been proven to affect productivity in a negative way (Ahmad et al., 2020; Pieper, 1991).

Another main aspect is the implementation challenges of research. Even though research has presented solutions to potentially increase long-term productivity, it has been shown to be difficult to realize, and reports conclude that the reason for this could be a lack of experienced workers (Alinaitwe et al., 2007; Aziz & Hafez, 2013; Delarue et al., 2021; Enshassi et al., 2007) and/or a lack of financial incentives for the construction workers (El-Gohary & Aziz, 2014; Enshassi et al., 2007; Kazaz & Ulubeyli, 2007). In addition, the project-based structure of the construction industry makes it hard to implement innovation from one project to the next, and it seldom brings out long-term changes in the field. Kadefors (1995) and Larsson (2012) underline that the procurement methods traditionally used in Sweden in some specific cases become obstacles. Worth mentioning is the interesting finding by Larsson (2012) regarding productivity implications due to a lack of work repetition possibilities.

Despite the reported difficulties in changing this trend, research lists potential strategies. While the main focus of the performed research is on the production stages, there is some research focusing on structural and early conceptual design stages. With regard to production, standardization in the sense of prefabrication has been studied by, e.g., Larsson (2012), Larsson et al. (2014), Larsson and Simonsson (2012). Concerning design stages, design for buildability and constructability is underlined, as well as higher quality in design reviews (Hanna et al., 2010). Achieving buildable solutions is best done by involving the contractor in the conceptual design stage (Antonsson et al., 2022; Haugen et al., 2017; Wondimu et al., 2016a). Digitalization is also attributed to design activities (Barbosa et al., 2017), as it allows for a more detailed design earlier in the process, which will help to make the right decisions and improve the planning of the coming work (Albinsson, 2019; Poirier et al., 2016).

The construction industry seems to be highly driven by financial incentives. How financial incentive programs for construction workers may drive productivity has been studied by Laufer and Borcherding (1981). It has also been shown that financial incentives could have a positive influence on project success and that they have the potential to align client and contractor objectives (Rose & Manley, 2010). A question may be asked if these incentives are short-term (project perspective) or long-term (company and/or sector perspective).

Even though numerous studies have investigated drivers and/or barriers to productivity in the construction industry, there is little research output on how and if the different actors' incentives could underlie the lack of long-term productivity increase. The purpose of this study was, thereby, to study productivity aspects with a lens of actors' incentives and, at the same time, examine if these incentives obstruct long-term productivity increase, in the Swedish bridge construction industry.

The following research questions define the purpose:

- RQ1. What aspects do the bridge-building industry consider as important for a long-term productivity increase?
- RQ2. What aspects are considered as important for a long-term productivity increase by the bridge-building industry in Sweden?
- RQ3. What actor-specific incentives are considered to obstruct long-term productivity increase?

2. Theory

2.1. Productivity

Productivity as a term has several definitions. The Organization for Economic Co-operation and Development [OECD] defines it as "the relationship between output and the input that is required to generate the output" (OECD, 2001); while the New Zealand Department of Housing and Building defines productivity as "the measurements of inputs and output resources" (Kenley, 2014). In this study, productivity follows the definition given by Nilsson et al. (2021): "Productivity means that the value added to the product increases despite the same amount of resource being used as before, or that the need for resource decreases to produce the same value".

Most studies on construction productivity measure it as an average of labor productivity (Abdel-Wahab & Vogl, 2011). Different client demands have been shown to be a major driver for productivity in the construction industry (Delarue et al., 2021; Ozorhon et al., 2016). Productivity has been shown to be lower compared to other industries due to a lack of research and development investments (Delarue et al., 2021). Inovation is one way to increase the productivity (Delarue et al., 2021; Goodrum & Haas, 2000; Slaughter, 1998).

In the work done by Allmon et al. (2000), it was found that new technology may be the primary driver for improving productivity in the construction industry. Standardization by prefabrication has been found to be a driver for productivity as it makes it easier to plan for upcoming work (Ozorhon, 2013; Seadon & Tookey, 2019) and the lack of adoption of prefabricated construction is seen as a barrier to productivity (Ofori et al., 2020). However, studies have shown that contractors are slow to implement innovations; the reason for this could be that the contractors often want to build with methods that have shown to be profitable in the past (Slaughter, 1998). Other studies have found that contractors are not interested in investing in new methods of construction since the return on the investment is not guaranteed (Ghosh et al., 2012; Ozorhon, 2013; Ozorhon et al., 2016). It has also been found that contractors do not usually innovate on their own, and here, the client has an important role (Ozorhon, 2013). Another reason that innovation is slower in construction compared to other industries could be that, in the construction industry, innovation exists within a temporary alliance (Slaughter, 1998).

Even though much of the existing literature agrees that the productivity in the construction industry is lower compared to the entire economy, there are studies that indicate that the industry has had a productivity growth. In the work done by Abdel-Wahab and Vogl (2011), they mention that there is a difference between the micro-level (measured activities) and the macro-level of productivity. The productivity improvements that are measured at the micro-level are not captured when measuring the overall productivity performance (Goodrum et al., 2002). In that study, they measured 200 activities, and 107 activities showed a productivity increase; 30 declined, and 63 were unchanged in the study by Ahmad et al. (2020) concludes that there has actually been a productivity increase at the macro-level. They also conclude that the way that construction productivity is measured (on-site production) fails to capture the entire productivity growth in the industry. In fact, much of the productivity growth instead goes to the manufacturing industry. In addition, there is a common understanding that developing regulatory requirements lead to higher durability and, in turn, quality. Even if this lacks empirical evidence, as it is hard to assess quantitatively, it is an essential factor in the correlation between quality and productivity, as productivity might go down with increased quality, as indicated by Pieper (1991).

2.2. Different project delivery models for contractors

Earlier research has shown that different Project Delivery Models (PDM) have different possibilities for high productivity. For different PDMs, this research focuses on Design-Bid-Build (DBB), Design-Build (DB), and Early Contractor Involvement (ECI).

In DBB, the client contracts a design company and a contractor separately. The design company provides complete design documents that the contractor should bid on and execute after. A significant disadvantage of DBB is that construction experience is not included in the design since the design is often performed by a design engineer who lacks construction experience (Wondimu et al., 2018). Different contractors may also have different experiences, which are not considered in DBB models. Another difference between DBB and DB is where the responsibility lies. For DBB models, the responsibility lies with the client, while for DB models, the responsibility lies with the contractor (Lædre et al., 2006).

In DB, the client contracts with one single part to perform design and construction (Haugen et al., 2017; Sanvido et al., 1998). Design-Build models could be seen as a better way since the contractor then becomes involved earlier in the process and could contribute with their buildability knowledge and ensure that the design is made for construction, which would increase productivity (Haugen et al., 2017; Jergeas & Van der Put, 2001; Simonsson, 2011; Wondimu et al., 2016a). Projects that have been procured with DB models have been shown to be built faster and/or at a lower cost compared to similar projects procured with DBB models (Hale et al., 2009; Ibrahim et al., 2020; Okere, 2018; Sanvido et al., 1998; Shrestha et al., 2012). Projects delivered with DB are often procured at a fixed price, and research has shown that fixed price gives higher productivity compared to variable price (Barbosa et al., 2017). However, contradictory results could be found on whether projects procured with DB models perform better than projects procured with DBB models (Ibbs et al., 2003; Park & Kwak, 2017).

Being able to involve the contractor earlier in the process has led to a number of novel project procurement forms; one of them is ECI (Walker & Lloyd-Walker, 2012). ECI usually consists of two phases, where phase one consists of project definition and design, and phase two is project execution (Walker & Lloyd-Walker, 2012). During the first phase, the client and the contractor should agree on a target price for executing the project during the second phase. ECI has been shown to be an enabler of innovation (Ozorhon et al., 2016). Research has shown that all complex projects can potentially benefit from ECI (Wondimu et al., 2020). By involving the contractor earlier in the process, the buildability and the cost estimations will improve (Linderfalk & Ljungqvist, 2020). Improved buildability depends on the designers' and contractors' ability to see the construction process through each other's eyes (Lu et al., 2021). ECI is one way to achieve better collaboration and to achieve this; the client needs to be proactive (af Hällström et al., 2021). In ECI, there is often a possibility of having different financial incentives, which is an important motivator for contractors to perform the work in an efficient way (Rose & Manley, 2011). However, it is debated whether the contractor has the possibility to affect productivity if involved this early. Antonsson et al. (2022) showed that the contractor thought that there were a lot of things that influenced the outcome that they could not affect. In work done by Simonsson (2011), ECI is one of four main factors for increased productivity and, together with lean construction, has the potential to reduce waste (Wondimu et al., 2016b). However, one disadvantage with ECI could be that the price when entering phase two is rarely exposed to competition. One way to solve this could be to let more than one contractor develop the target price, which is described by Wondimu et al. (2020).

2.3. Different forms of compensation for design engineers

Different forms of compensation for design engineers (design engineers are structural engineers working with bridges in this paper) and the ability to affect productivity are research areas that have not been explored very well. Research has shown that engineers tend to produce better quality and more innovative designs if they have financial incentives (Love et al., 2010). In the same research, interviewed contractors also think that it is profitable for them to share a greater part of their own reward since this will motivate the engineers to develop buildable solutions. Having a fixed price has been proven to increase the productivity of engineers since that will increase their profit, but it might not result in the best solution for the client (Eikeland, 2001). Engineering productivity has also been shown to be less understood than construction labor productivity (Kim, 2007). Declined engineering productivity does not have to be negative for the total productivity in a project. Engineers tend to spend more time with 3D CAD compared to 2D CAD, but this has helped the engineers deal with constructability and safety issues beforehand (Liao et al., 2012). Looking at the individual level, engineers mention bonuses as an incentive that will motivate them to perform better (Banker et al., 1996).

3. Method

For this research, a questionnaire was chosen as a time-efficient way to collect responses (Bell et al., 2018). A questionnaire was considered to give a nuanced result and enable data collection from an essential part of the Swedish bridge engineering sector. Questionnaires have also been found to be the most preferred data collection method within the construction productivity research (Hasan et al., 2018). Since the answers were anonymous, the respondents could be open with their answers. The scientific approach consisted of a pilot-questionnaire, data collection by a questionnaire, and a statistical analysis. For the quantitative study, the following steps presented by Blair et al. (2013) have been applied:

1. Overall survey design and planning;
2. Questionnaire design and pre-testing;
3. Final survey design and planning;
4. Sample selection and data collection;
5. Analysis of data.

3.1. Survey design

The authors developed the questionnaire in workshops based on their industrial and academic experience. Second, a pilot test was distributed to six representatives from clients, contractors, and design engineers to determine whether the questions were understandable and relevant. This procedure is described as one way to increase the questionnaire's quality (Bell et al., 2018).

The purpose of the pilot test was to identify aspects that could be incentives and serve as a basis for the questionnaire. From the authors' industrial and academic experience and the answers and comments of the actors' representatives, the following aspects were derived:

- Project delivery model;
- Compensation formats for engineers;
- Reduced climate impact;
- Quality of delivered products;
- Profit in a single project and long-term increased company profit;
- Production time;
- Work environment.

After minor revisions, a final version was distributed in September 2021, and it was available for 19 workdays. The final questionnaire had 24 questions. Except for demographic questions, e.g., about discipline, age, and time in the industry, the respondents were asked about productivity in the design and production of bridges. The questions focused on both organizational and technical aspects. This paper focuses on the organizational aspects.

The questionnaire required the respondents to rank statements about productivity on a 7-point Likert scale. The authors chose a 7-point Likert scale instead of a 5-point Likert scale. The 7-point Likert scale provides a more nuanced but is still simple enough for respondents to answer (Joshi et al., 2015). In addition to a 7-point Likert scale ranking, for one question, the respondents were asked to rank the statements against each other to discern relative distinctions between the statements. For every question, the respondent could add an additional alternative answer and/or comment.

3.2. Sample selection and data collection

It was decided to distribute a short questionnaire since this improves the chances for a higher response rate. To further increase the response rate, the respondents were given a short introduction to the survey's aim. Finally, the response rate was increased by reminding individuals who had not responded or who had not finalized the questionnaire. The questionnaire was distributed in September 2021 and was available for 19 workdays.

All the respondents were guaranteed full anonymity. At the survey's beginning, all respondents were asked if their answers could be used for research purposes; if they answered no, the questionnaire was closed for them, and they could not finalize it.

The sampling frame comprised design engineers, contractors, and clients from the largest actors in the Swedish bridge construction industry. The questionnaire was distributed by e-mail to 470 recipients, out of which 175 were design engineers at eight large engineering consultancy companies, 246 contractors at nine different companies, and 49 clients from the public client. Some of the contractors have technical departments that could be seen as "in-house-designers". The e-mail addresses were collected through personal contacts at each of the companies. All the collected e-mail addresses were used for the distribution of the questionnaire.

With a registered population of 470, the sample size should be at least 80 to achieve a 95% confidence interval and a 10% margin of error. In this study, 151 valid responses were collected, indicating adequate sample size. Out of the 151 respondents, 76 were design engineers, 37 were contractors, and 38 were clients. The respondents' distribution of experience in the industry is presented in Table 1.

Table 1. Experience distribution among respondents

	0–10 years	11–20 years	21–30 years	30+ years	Total
Design Engineer	30	25	14	7	76
Contractor	5	12	9	11	37
Client	4	15	11	8	38
Total	39	52	34	26	151

3.3. Analysis and validity/reliability

The responses from the questionnaire were analyzed by sorting the 151 respondents' answers into categories by actor type and their corresponding Likert-scale score. The formula for calculating the ranking is given in Eqn (1), where $\bar{X}$ is the average rating for the specific question, and n_1 to n_7 are the number of respondents who responded 1 to 7.

$$\bar{X} = \frac{1(n_1)+2(n_2)+3(n_3)+4(n_4)+5(n_5)+6(n_6)+7(n_7)}{n_1+n_2+n_3+n_4+n_5+n_6+n_7}. \quad (1)$$

In addition to the rankings and the Likert-scale score, correlations matrices were studied to find out the consistency among the respondents' answers. The derived Likert-scales, ranked answers and correlation matrices were analyzed and discussed in detail by the authors during several sessions.

The replicability of the questionnaire is considered high since all the questions will be available to other researchers. The reliability is also assessed by using Cronbach's α coefficient. This measures the internal consistency, and the reliability is satisfied when Cronbach's α coefficient exceeds 0.7. For the questions in the questionnaire, Cronbach's α was found to be 0.844, which indicates high reliability. Replicability is considered important for the reliability of quantitative studies (Bell et al., 2018).

The validity of the quantitative study increases with the number of respondents. In comparison to other quantitative studies that have used questionnaires within the Swedish bridge-building industry, see e.g. (Ekström et al., 2019; Larsson & Simonsson, 2012; Simonsson, 2008), this questionnaire received more responses. The validity of the results also depends on whether the respondents understand the questions, and the pre-testing described in Section 2.1 was considered to increase the validity of the questionnaire.

4. Findings and discussion

In this Section, the findings are presented and discussed based on the Likert-grading for the studied aspects and a ranking table for the ranking question. In addition, the correlation between the top-three ranked aspects and their corresponding Likert-grading is discussed.

It was important to find out which of the different project delivery models that are used in the Swedish infrastructure sector the different actors thought had the greatest potential to create the right circumstances for improved productivity; the respondents' answers are shown in Figure 1.

For the project delivery models, the client and contractor thought that DB was the delivery model that had the best potential for improved productivity. The design engineers, on the other hand, thought that ECI had the highest possibility of improving productivity. That both the client and the contractor believe more in DB than ECI was surprising, especially since the early involvement of the contractors should pave the way for better buildability and, thereby, better productivity, at least in theory. ECI has the potential to obtain the best contributions from the project participants (Rahmani, 2020) and to bridge the gap between design and construction (Nibbelink et al., 2017). ECI with different financial incentives is also a way forward in order to increase productivity (Rose & Manley, 2010, 2011). One reason why contractors found DB favorable could be that ECI fails to have a proper win-win share (Rahman & Alhassan, 2012; Rosander et al., 2020). Viewing DB delivery models as more efficient contradicts earlier research, which views ECI as a more promising (Antonsson et al., 2022; Linderfalk & Ljungqvist, 2020; Rahmani, 2020). Another reason that the DB delivery was considered to create more productivity could be that the experiences from ECI are still quite limited in Sweden since they have only been used for seven years (Rosander et al., 2020). To further increase the knowledge about the possibilities with ECI and to reach its full potential, we believe that the client needs to be proactive and keep procuring projects with this PDM. Concluding we can state that there is no clear PDM that the actors believe would have great potential for productivity. This is something the client needs to work with to find a PDM that would increase productivity in the industry.

To be able to create the right conditions for design engineers, it is important that they have an attractive financial incentive that makes it possible for them to strive for increased productivity in design. The results show that most of the actors think that variable price is the form of compensation that creates the best conditions for productive design, see Figure 2. It is worth mentioning that the respondents were not very positive about any of the two suggested compensation formats for design engineers.

The result is in contradiction with Eikeland (2001), who states that a variable price model will not motivate the design engineers to be productive but rather to spend more hours. The Swedish Transport Administration (STA) has, for the last few years, increased the number of design assignments compensated by a fixed price model as one instrument to increase productivity in engineering work. When applying a fixed price model, the contractual requirements need to be well defined. In addition, a fixed price model is, according to previous research (Kristensen et al., 2015; Lædre et al., 2006), mainly applicable for the stage with detailed design for tender documents in a DBB procurement. Productivity requirements in the design with a variable price model could certainly increase productivity during construction. Therefore, it would be necessary to find a new financial form of compensation for engineers that would increase their incentive to strive for high productivity. Low design fees, selection of design firm by

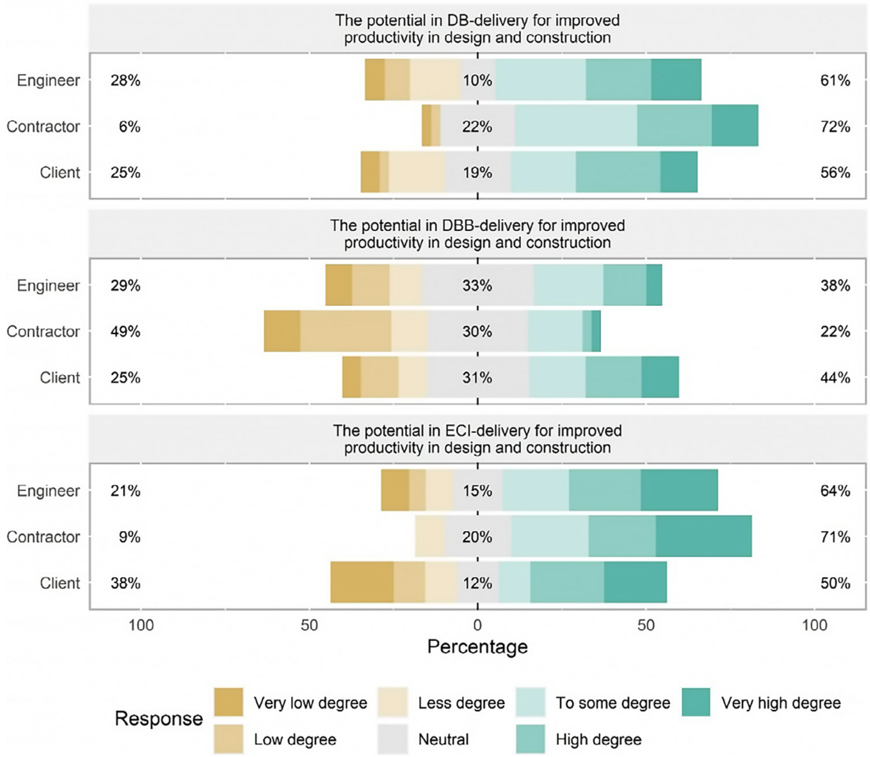

Figure 1. Different project delivery models for contractors (in the figure, the engineer is the design engineer procured by the client). The percentages indicate how the respondents answered with regard to neutral

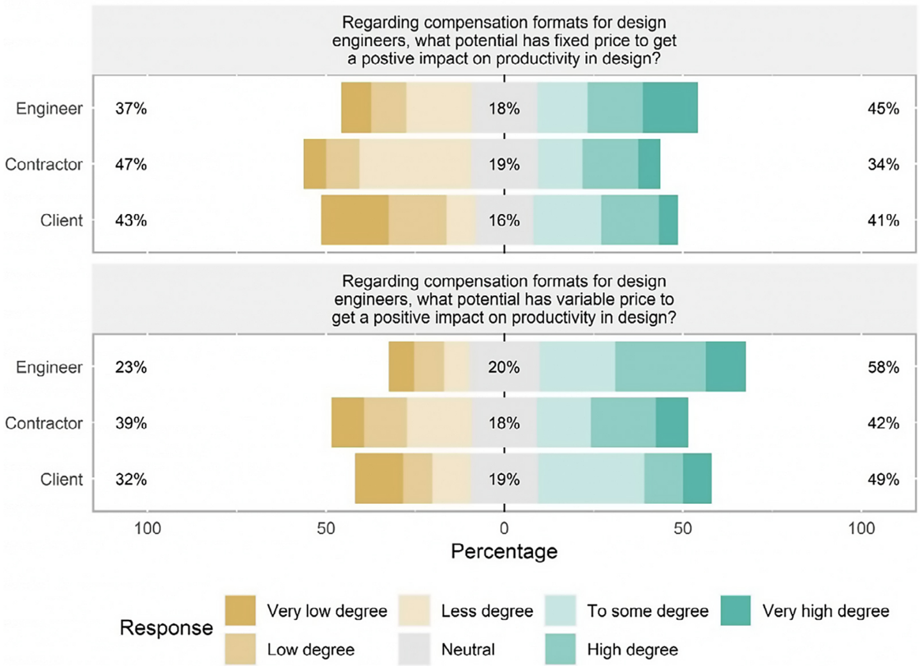

Figure 2. Form of compensation for design engineers (in the figure, the engineer is the design engineer procured by the client). The percentages tell how the respondents answered with regard to neutral

lowest price, and lack of time were important aspects that influenced the quality of the design documents (Akampurira & Windapo, 2018); these reasons further strengthen the need for new financial incentives such as well-defined productivity requirements for design engineers. From a client's point of view, the product from the design engineers needs to be designed to make it possible to achieve high productivity during construction. The main finding from this question is that the two compensation formats that were considered are not perceived as supporting productivity. This is also something that the client needs to work with to find attractive compensation formats for design engineers that have the potential for increased productivity.

When we asked about the importance of six different aspects, regarding quality, production time and profit, it can be observed that all aspects are considered as important to semi-important to all actors. In addition, a consensus regarding "quality of delivered product" as highly important for productivity is observed. However, the results differed between the three actors with regard to climate impact, production time, work environment, and profit. For the contractors, the "work environment" and the "quality of delivered products" were considered as most important, the client had "quality of delivered products" as most important, and for the design engineers, the most important was "the company profit over time". The three actors' responses to these six aspects are presented in Figure 3.

For aspects presented in Figure 3, the participants were asked to rank these. This was done to distinguish whether any aspects received the same points. This shows that the results became different when the respondents had to choose and rank the different aspects against each other. The most important aspect for the design engineers and the client was the quality of delivered products, and for the contractor, the most critical aspect was still the work environment. The questionnaire result confirms earlier research that also found the importance of the work environment and the quality of delivered products (Larsson & Simonsson, 2012), and in which it was concluded that the use of prefabricated parts fulfils both of these in a better way than on-site production. Earlier research has also concluded that improving worker safety and productivity simultaneously (Choudhry, 2017) is possible. Table 2 presents the aspects ranked by the respondents. Numbers in parenthesis is how they answered depending on the experience distribution as presented in Table 1.

When the respondents were asked to rank the different aspects, the three most important aspects for the contractor were "Work environment", "Profit in a single project" and "Quality of delivered products". One aspect "Quality of delivered products" is ranked top-three by all actors. That the contractor valued the profit in a single project over the company profit over time is interesting. This implies that the contractor is not willing to invest in a single project unless it pays off directly, which confirms what has been concluded in earlier research (Delarue et al., 2021; Ozorhon, 2013; Ozorhon et al., 2016). This could be because many companies have some incentive program that depends on the profit of a single project. This is much in line with the project-based organization structure of the contractor firms, which focus on the projects and the profit from the projects and less on the company profit over time. Several researchers report that financial incentive programs are essential for construction workers (El-Gohary & Aziz, 2014; Kazaz & Ulubeyli, 2007).

When looking at how each actor responded within the different experience distributions, it can be observed that they agree very well on every aspect.

The aspect "Profit in a single project" is the aspect that varies mostly between the contractors' and the clients' ranking. While the client considers this aspect as the least important for productivity, the contractor ranks it as the second most important for productivity. Developing solutions that could be used in many projects might, therefore, not be interesting for the contractors, even if the profit in the upcoming projects may increase. For the Client, in this case, a public client, it is most probable that profit in a single project seldom or never is an incentive for productivity. In addition, the client probably can't see their role for long-term productivity, as their strongest incentive is the quality of the delivered product; on this basis, it can be argued that these misaligned financial/quality incentives result in obstacles to increased productivity over time. The implication of this result is essential for the client. If they are interested in increasing productivity, they need to be proactive and design the procurements to encourage the contractor to take initiatives that could increase long-term productivity and still make a profit in that single project. The main finding from the ranking is how the contractor ranks profit. It is more important to focus on short-term single project profit than long-term profits. Together with the question about PDM, this is important for the client to consider when procuring a project. If the client has ideas that they believe can improve long-term productivity, the procurement needs to be designed in a way that the contractor can make a profit in that project and realize that this has the potential for long-term productivity increase.

One important thing to mention is how the reduction of climate impact was ranked. None of the actors ranked this item among the top three to support increased productivity, and it was also considered the least important for the contractor. This result contradicts the findings by Ozorhon (2013), where environmental sustainability was considered an important aspect of enhancing productivity. Reduced climate impact was considered the fourth most important aspect among the clients; this contradicts Lagerkvist et al. (2021), where it was expressed as one of the most important goals that the Swedish Transport Administration has. If they should be able to reach the goal of reducing climate impact (Miljömålsberedningen, 2016; Trafikverket, 2021), they need to find economic incentives for the contractor to work for this. To reduce climate impact, both the client and the design engineers have an important role, and as Lagerkvist et al. (2022) and Rempling et al. (2019) states that a smarter design has great potential to reduce cost and climate impact.

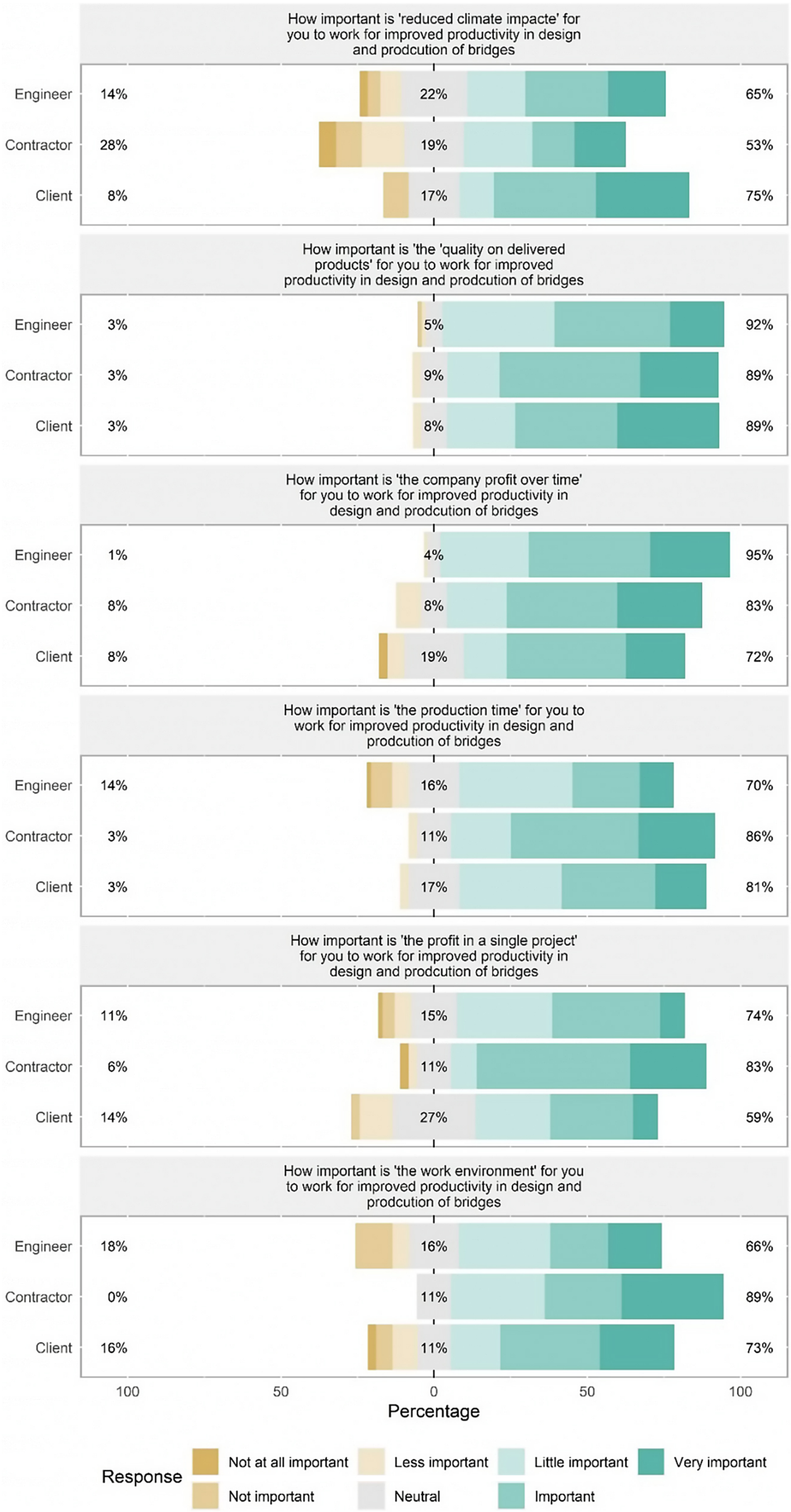

Figure 3. Important aspects for working for increased productivity in the design and production of bridges (in the figure, the engineer is the design engineer). The percentages tell how the respondents answered with regard to neutral

Table 2. Aspects ranked by the respondents (ranks from 1–6 where 1 is most important and 6 is the least important). Numbers in parenthesis are ranked depending on the experience distribution (0–10 years, 11–20 years, 21–30 years, and 30+ years respectively)

Aspect	Design engineer	Contractor	Client
"Work environment"	4 (3, 5, 3, 4)	**1** (1, 1, 1, 2)	**2** (3, 1, 2, 2)
"Quality of delivered products"	**1** (1, 1, 2, 1)	**3** (4, 2, 4, 3)	**1** (1, 2, 1, 1)
"Profit in a single project"	**3** (4, 3, 4, 3)	**2** (2, 4, 2, 1)	6 (6, 6, 4, 6)
"Company profit over time"	**2** (2, 2, 1, 2)	5 (5, 5, 3, 4)	**3** (4, 3, 3, 3)
"Production time"	6 (6, 6, 6, 6)	4 (3, 3, 5, 5)	5 (5, 5, 5, 5)
"Reduced climate impact"	5 (5, 4, 5, 5)	6 (6, 6, 6, 6)	4 (2, 4, 6, 4)

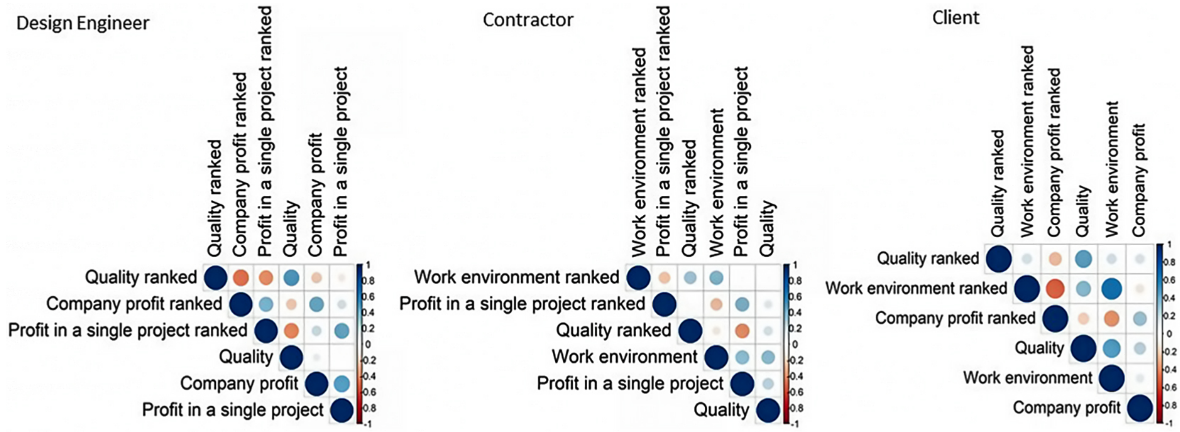

Figure 4. Correlation matrices for the top-three ranked aspects for each actor. For the analysis, the correlation between the top-three ranked aspects and the corresponding 7-Likert-scale grade. For the analysis, the ranking was converted into grades, i.e., the highest rank was graded with a 7, the second highest with a 6, and so forth

Correlation matrices were developed to analyze the correlation between the top-three ranked aspects and the corresponding 7-Likert-scale grade. For the analysis, the ranking was converted into grades, i.e., the highest rank was graded with a 7, the second highest with a 6, and so forth. In Figure 4, a correlation matrix of the top-three aspects of each actor is presented; the main observations are:

- A high correlation can be observed for each aspect and actor, except for contractor/Quality of delivered product.
- The contractor grades the quality of the delivered product (89%) higher than the profit in a single project (83%) but ranks the profit higher than the quality. Even though the grade difference is slight, it can be concluded that the higher rank of the work environment and profit is a more honest and more significant incentive for productivity.

5. Conclusions

Numerous studies have investigated drivers and barriers to productivity in the construction industry. However, little attention has been given to the paradox that actors' specific and diverging incentives may threaten long-term productivity. This study aimed to identify such aspects that could be incentives and obstacles to long-term increased productivity in the bridge construction industry. To fulfil the aim, a questionnaire study was carried out in this study.

The important conclusions drawn from the study are as follows:

- "Quality of delivered products" was ranked in the top 3 among all three actors.
- "Work environment" was considered important for the client and the contractor.
- "Company profit over time" was ranked as top 3 among the design engineers and the clients. This insinuates that the contractors are less willing to invest in things that cross projects unless it pays off directly in the current single project.
- "Profit in a single project" was ranked higher than "Company profit over time" among the contractors.
- There is disagreement among the actors regarding which project delivery model has the best potential for productivity increase.

From our study, the recommendations would mainly be for the clients and to work with procurement to find the right incentives for design engineers and contractors to strive for long-term increased productivity. The client must consider overall productivity and not look at different parts separately.

This study has only studied conditions in Sweden. However, since a significant part of the developed countries face the same problems, the results from this research could be applicable from an international perspective. For future research, similar studies in other developed countries would be needed to find out if there are any differences between countries.

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