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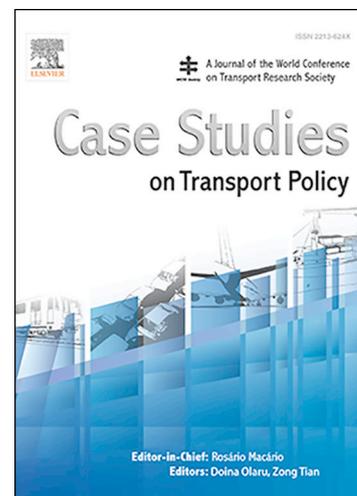
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Barriers to spurring innovation in Swedish transport infrastructure construction

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Abstract

The construction industry is struggling with declining productivity. As Sweden's largest public-sector purchaser of construction services, the Swedish Transport Administration launched a programme aimed at increasing productivity. One important component of this programme was the introduction of

design-build procurement to increase the leeway provided to contractors to identify innovative and efficient solutions. In this case study of the programme, which focuses on design-build contracts, we have conducted 27 interviews with Swedish Transport Administration project managers, contractors, and consultants to examine how successful the implementation of some of these measures has been and what hurdles they have encountered. Our results show that, in many regards, the programme has failed to increase innovation and productivity. To a large extent, this can be attributed to legitimate reasons such as the integrity of the planning process and standardisation of the railway. That said, we have also identified a perceived lack of competence among both project managers and contractors, as well as an apparent lack of trust between them. One important conclusion is that the Swedish Transport Administration has failed not only to implement design-build contracts, but also the structure to make the contracts they have implemented work, in particular the failure to provide project managers with incentives to experiment. We also conclude that, if used incorrectly, this type of procurement could even have a detrimental effect on innovation.

1. Introduction

The slow growth in productivity in the construction industry is a global problem that has seen building become increasingly expensive relative to other industries (Nilsson et al. 2019). Between 1990 and 2015, a period during which consumer prices in Sweden increased by 40 per cent, construction costs increased by approximately 150 per cent. These spiralling costs prompted several government inquiries into how productivity might be increased. As a result, the Swedish Transport Administration, Sweden's largest public-sector purchaser of construction services, launched a programme aimed at increasing productivity and innovation throughout the industry (Transport Analysis 2017).

One significant element of the productivity programme is the implementation of design-build contracts, which it is hoped will provide contractors with greater freedom and flexibility than the more traditional design-bid-build contracts, in the expectation that this will increase both productivity and innovation. While this presumption is underpinned by theoretical (Williamson 1975) as well as some empirical evidence (Shrestha et al. 2012), any potential gains from design-build contracts are contingent on their successful implementation.

In this paper, we set out to study the implementation of design-build (DB) contracts by the Swedish Transport Administration in order to identify barriers to their implementation. The study is based on 27 interviews with representatives from 10 infrastructure projects in Sweden. The results may also prove relevant to anyone outside Sweden seeking to improve the productivity of their own construction industry. The paper does not address the efficiency of design-build contracts.

The paper is structured as follows: in Section 2, we provide background on design-build contracts, productivity and its decline in the Swedish construction industry and initiatives by the Swedish Transport Administration to reverse this trend; in Section 3, we present the method used and the cases studied; in Section 4, we present the results of our interviews; in Section 5, we discuss the results; and in Section 6, we present our conclusions.

2. Increasing productivity in the construction industry

2.1 What is productivity?

Productivity is typically defined as the output obtained from any given amount of input (Syverson 2011). Although easy to define, productivity is more complex to measure at a micro level, given that in many cases the value of the output is difficult to determine. In road and rail construction, however, the fact that output is so tangible makes this less of an issue.

There are two main ways in which productivity can be improved. The first is by simply using the inputs more efficiently. This is the mechanism at work whenever an individual or organisation accumulates experience and organically become better at what they do. This can either be achieved by sticking to what you know and fine-tuning your process, or through *process innovation*. Process innovation is essential to improving output value since fine-tuning has limited scope for improvement. The second way is to improve the output, or *product innovation*.

Although the government's directions to the Swedish Transport Administration state that it should *in its role as a purchaser work to improve productivity, innovation and efficiency on the markets for infrastructure investments, operations and maintenance*, implying that the administration should be working towards product innovation, the focus has been on process innovation, as we will describe in the remainder of this section.

2.2 Design-Build or Design-Bid-Build?

In the design-build procurement processes, the customer invites tenders to design and build the project, meaning that the main contractor is responsible for both. In more traditional design-bid-build contracts, the customer decides what it wants to build, designs it (or employs a contractor to do so) and then puts the building contract out to tender. As one of the primary measures taken by the Swedish Transport Administration to increase productivity, it was intended that over 50 per cent of procurements would be for design-build contracts, a goal the Swedish Transport Administration reported it had achieved in 2016 (Transport Analysis 2017).

The rationale behind the move from design-bid-build to design-build was that the party best suited to handle any specific risk is the party that should do so. In the context of construction, this means that the contractor should be the one to handle building-related risks – and should therefore also be given the freedom to deal with them. This freedom and responsibility should, in theory, lead to contractors investing in innovation which in turn should improve productivity. However, if these contracts are to be beneficial, the transaction costs arising from policing and governing these contracts, as well as any rent-seeking on the part of the contractor, must be lower than the productivity gains (Williamson 1975).

Empirical evidence regarding the gains achieved through design-build contracts is quite scarce. Both Nyström et al. (2016) and Shrestha et al. (2012) provide an overview of the empirical literature. They find that the use of design-build contracts appears to be more widespread when building housing and industrial units than when building infrastructure. Most studies therefore look at these sectors, where design-build contracts have been shown to shorten delivery times. Studies of the efficacy of design-build in the infrastructure sector are thinner on the ground; however, in their study of 6 design-build and 16 design-bid-build contracts, Shrestha et al. (2012) find that design-build contracts result in faster highway construction. More evidence is however available from public-private partnerships (PPPs), which follow the same rationale, i.e., that the party best suited to handle risk should do so. In their literature review, Jin & Zhang (2011) conclude that risk is often managed poorly in PPPs, leading to increased risks for both the public and private-sector partners.

There are good reasons why design-build contracts have not been widely utilised in public infrastructure projects such as roads and railways. One such is that the public procurement process is not designed to promote productivity but to curb corruption and nepotism (de Valence 2010). In such a situation, it is perfectly rational to clearly define what the contractor is to build, as a design-bid-build contract does, in order to limit the degree of freedom in assessing the tenders. In design-build contracts, where the final design is unknown at the time of tendering and contractors compete with their capacity for innovation (Österberg & Qvist 2018), the scope for nepotism is substantially higher.

2.3 The Swedish pursuit of productivity

Between 1990 and 2015, a period during which consumer prices in Sweden increased by 40 per cent, the cost of building roads and railways increased by 110 and 179 per cent respectively. These spiralling costs were one of the reasons for the reorganisation of the Swedish transport sector a decade ago, when the Swedish Road Administration and the Swedish Rail Administration were merged into one organisation, the Swedish Transport Administration. The ambition was that this merger would increase knowledge of how to improve the function and efficiency of the civil engineering market, as well as to increase innovation (Dir. 2008:90).

Since the creation of the new administration, there have been government commissions of inquiry (Productivity Commission 2012) and reforms aimed at improving productivity. There have also been initiatives at the Swedish Transport Administration, many of which have originated at the administration's Productivity Office, a project group set up partly to promote a new mindset within the organisation and partly to launch specific projects aimed at improving productivity. One important component of this effort has been the introduction of design-build contracts. To facilitate the necessary shift, the Swedish Transport Administration set about changing the essence of its organisation from an infrastructure provider to a procurement organisation.

This altered mindset is perhaps the most significant change to the Swedish Transport Administration since its creation in 2010 (Witzell 2019) and has been described as the "pure purchasing organisation" Österberg & Qvist (2018). Österberg & Qvist (2018) describe the reform as a way of increasing productivity by competition. To increase competition, the Swedish Transport Administration went from taking an active role in day-to-day activities to participating as a facilitator and "handler" of the contractors. As a part of this "pure purchaser organisation", a new function for strategic procurement and purchasing (SISU) was established.

The pure purchaser has not been the only initiative to increase productivity. The Swedish Transport Administration has also taken several measures aimed at increasing the level of freedom afforded to contractors, as a means of encouraging innovation. For example, the Swedish Transport Administration has overhauled its guidelines and requirement specifications in order to be able to focus on function rather than the nuts and bolts of projects, as well as taking measures aimed at improving industrial production, which is known to be more complicated in project-based industries than in manufacturing. The measures taken to facilitate industrial production include combinatorial bidding and more flexible starting dates and deadlines. All these measures are, to some extent, aimed at increasing the leeway given to the contractor in terms of implementing the contract.

In summary, the Swedish Transport Administration's efforts to increase innovation and productivity can be divided into three categories:

- 1) More flexible tendering and new contract forms.
- 2) New project organisations, with a less hands-on, more facilitative approach.
- 3) Reformed guidelines to allow for new methods and components.

2.4 Can we expect DB-contracts to improve productivity through innovation?

A core tenant of the STAs pursuit of enhanced productivity is innovation in DB-contracts. The idea is that more degrees of freedom will lead to experimentation which will lead to innovation which in turn will improve productivity. This chain hinges on 1) that DB-contracts provide more freedom and 2) that contract managers use this freedom to experiment. As Niskanen (1968) pointed out, it is not necessarily the case that bureaucrats, in this case project managers at the STA or the contractors, will do this if their personal incentives do not encourage them to do so. There has been a lot of development and criticism of Niskanen's theory regarding bureaucrats' motivations (Migue & Belanger 1974) and inefficiencies of tendering (Williamson 1975, Frey 1993) (Niskanen's recipe to the inefficiencies induced by the misalignment of public and bureaucrat incentives is to a large extent to put work done by bureaucrats up for tender). To formalise the "innovation chain" we develop a simple model of the STA and project managers.

The STA strives to maximise infrastructure output (R) over n periods with interest rate r

$$V_{STA} = \sum_i^n \frac{R_i}{(1+r)^i}$$

In every time period it can choose to allocate its budget (M) to any combination of infrastructure construction and innovation (I), with p being the corresponding unit prices in each time period

$$M_i = p_{Ri}R_i + p_{Ii}I_i$$

The output of I in time period i lowers p_R in subsequent time periods, i.e. $p_{Ri+1}(I_i)$ where $p_{Ri+1}'(I_i) < 0$. The STA thus attempt to strike a balance between R_i and I_i so that the total output of R_i becomes as large as possible.

Innovation takes place in projects and is risky. That means that while \bar{I} is costly there exists a possibility that it holds a negative cost that can also be applied in consecutive periods. The difference on the project level is that innovation in period i can also be applied in period i . The project managers exist in one time period only and is evaluated by their infrastructure output, i.e.

$$V_{PMi} = R_i$$

Since project managers are not evaluated by their innovation output and since the average cost of innovation is positive, average project managers have no incentive to allocate funds to innovation. As such we would not expect project managers to engage in innovation. However, a simple extension of the model, for example where some project managers have a very high risk appetite (or are very confident that their experiment will succeed) would induce some project managers to innovate. However, given that they are not evaluated on their innovation output the main conclusion hold: we do not expect project managers to experiment (innovate) simply because they are given the freedom to. For them to do so, other incentives have to be in place. This holds for project managers at the STA as well as the contractors' project managers. In the case of the STA, no such incentives are in place. As such we do not expect the introduction of DB-contracts without the necessary incentives to lead to increased innovation.

3. Data and method

This paper is based on semi-structured telephone interviews conducted during winter 2016–2017 with people working on five road and five rail projects tendered by the Swedish Transport Administration as DB-contracts. These projects were selected by Transport Analysis, the government agency tasked with advising transport policymakers, including the Swedish Transport Administration as a part of

their work reviewing the Swedish Transport Administrations efforts to improve productivity. The interviews themselves, as well as a report (WSP 2017) presenting the findings were conducted and compiled by the authors while employed at WSP, a consultancy. As a method, the semi-structured telephone interview is well suited to qualitative research as telephone conversations naturally follow an agenda similar to semi-structured interviews (Cachia & Millward 2011). In an email survey, for example, we would not have been able to follow up on certain answers or pick up nuances as easily. For each project, our ambition was to interview the Swedish Transport Administration's project manager, the contractor's project manager and a consultant with good insight into the project. The aim was to provide a good overview and to capture different perspectives on the projects, as well as any discrepancies in their general view of the Swedish Transport Administration's productivity programme. The choice of multiple interviews across several contracts as opposed to deeper interviews focusing on fewer contracts was made to better be able to identify common factors and key differences.

The respondents were informed that they had been chosen for their role in a specific project but that, if they deemed it relevant, they were welcome to offer general comments as well. As many of the interviewees have years of experience in civil engineering and working for the Swedish Transport Administration, they were given the opportunity to elaborate on how they viewed development over time.

The interviews centred around three themes made up of ten questions, the full set of questions are available in Appendix 1 – interview questions. The themes were: 1) *Tendering and design*, which contained questions regarding the tendering process and to what extent the contractors could influence the design pre-tendering; 2) *Organisation and construction*, which contained questions regarding the interplay between the Swedish Transport Administration and the contractors during the construction process; and 3) *Post-construction reflections*, which contained questions regarding what had and had not worked well and how processes can be improved. The interviewer took notes during the interview, and these were then sent to the interviewee for approval and any comments.

A brief description of the projects and interviewees is presented in Table 1. The projects range widely, from minor improvement works to building new infrastructure. Unfortunately, we were not able to reach all respondent groups in all projects; still, the response rate was very high. A total of eight contractors are represented, market leaders as well as one local company, and six consultancies. These cover five out of the six regions into which the Swedish Transport Administration divides its operations. All in all, this provides us with a broad range of perspectives and a good overview of the industry and the country.

Table 1 - Project description and respondents

Project information			Respondents		
Project	Rail/Road	Description	Swedish Transport Administration project manager	Contractor project manager	Consultant
1	Rail	Improvement works on a railway line in southern Sweden.	X ¹	X	X

¹ The Swedish Transport Administration's project manager was replaced during construction. In order to get the full picture, both were interviewed.

2	Rail	Construction of new railway and commuter train station outside Stockholm.	X	X	
3	Rail	Construction of a bypass track on a major railway line in western Sweden.	X	X	X
4	Road	Construction of new motorway and bridges in northern Sweden.	X	X	X
5	Road	Construction of a new motorway interchange outside Stockholm.	X	X	X
6	Road	Road improvement in western Sweden.	X		
7	Road	Road widening in western Sweden.	X	X	X
8	Rail	Construction of a new railway, including bridges, in central Sweden.	X	X	X
9	Road	Construction of new motorway in western Sweden.	X	X	X
10	Rail	Extension of bypass track and construction of new tracks in northern Sweden.	X	X	

Since our only empirical evidence are these interviews it limits the conclusions we are able to draw. In interviews we collect the experiences and views of those interviewed. These experiences and views may or may not be accurate representations of reality. However, the risk of an outlying view having a large impact on our total data is managed by interviewing many different individuals, with different perspectives.

4. Results

The results presented below consist of answers and reflections given during the interviews and are presented in three parts mirroring the three categories of the Swedish Transport Administration's productivity efforts outlined in Section 2.3.

4.1 Tendering and design

Opinions on whether the introduction of design-build contracts has created greater freedom for contractors differ depending on who you ask. In about half of cases, Swedish Transport Administration project managers stated that tender documentation predominantly consisted of detailed specifications, in effect replicating a design-bid-build procurement. In the other half of cases, they stated that functional specifications were predominant, i.e., a design-build procurement. Even in those cases, the project managers admitted that the level of detail was fairly high.

The picture painted by the contractors differs from that of the Swedish Transport Administration's project managers. In all but one case, they stated that procurement documentation was highly detailed, the exception being a rail contract (1) where both the Swedish Transport Administration's project manager and the contractor stated that the procurement was a hybrid of the two forms. That both detailed and functional demands appear in the procurement documentation is, however, a reoccurring finding. In one case, a consultant supports the view of the contractor that the tender documentation was prepared for a design-bid-build contract and then simply relabelled as design-build.

Despite the contractors' frustration over the lack of flexibility, and in some cases even the burden of risk without the corresponding freedom to alleviate the risk, in many ways they are understanding of why the Swedish Transport Administration is struggling to make the transition to design-build procurement. Road and rail construction in Sweden is preceded by the development of a plan that determines the exact location of the road or railway, horizontally and vertically. The planning process involves the Swedish Transport Administration, the public and other stakeholders, but not the contractor, who must play the cards they have been dealt with regards to the position of the road. Even if they express frustration, most contractors recognise this. There are, however, examples of bridges that were predesigned, even though there was no reason to limit the design based on the road or railway plan in the same ways as the road or railway itself, something that the contractors found both strange and frustrating.

Limitations placed on railways are even more significant than those on roads. When working on the railway, the contractor must be allocated a timeslot. The application process for these timeslots starts over a year in advance and is very complicated. The length and frequency of timeslots has a significant impact on how trackwork can be performed, something that both the Swedish Transport Administration and the contractors recognise. While the contractors have a shared view of the problem, they do not necessarily agree on the solution. Some see early involvement in the procurement process or very long lead times between being awarded a contract and starting construction as the answer, while others feel that the Swedish Transport Administration should handle the scheduling process, as it is too complicated for the contractors. Another railway-related obstacle that has also been posited by other studies (e.g. Österberg & Quist 2018) is the high degree of standardisation of railway components. The reasons for this put forward by the Swedish Transport Administration is the need to have a good understanding of how components age and to reduce the number of different components they must stock for maintenance. Contractors, on the other hand, state that this makes it very difficult for them to introduce new, potentially cheaper components, as they must go through a complicated approval process. Here, the contractors express a great deal of frustration, stating that they could cut costs significantly by introducing cheaper components.

To some extent, the lack of flexibility in contracts could be alleviated by allowing contractors to influence the design in the procurement process. Both Swedish Transport Administration project managers and contractors stated that opportunities to do so were limited; in fact, one contractor stated that their opportunities to influence the design were no better than in a design-bid-build procurement. There are many reasons for this, including those presented above. There is also the possibility to submit an alternative tender to the conforming tender. One project manager at the Swedish Transport Administration stated that alternative tenders are pointless since the Swedish Transport Administration lacks the ability to evaluate them. If they do evaluate and later accept them, they are subject to appeal by other contractors.

4.2 Organisation and communication

Despite the new design-build procurement process, the Swedish Transport Administration must still approve the solutions presented by the contractors. If the contractor wishes to use a new method, this requires a great deal of communication between the contractor and the Swedish Transport Administration. In some contracts, colocation of the Swedish Transport Administration and the contractor is used as a way of facilitating this communication. The idea behind this is that this will keep the Swedish Transport Administration informed and available whenever the contractor has any questions or needs solutions approved. While based on the interviews this does seem to be a successful method at times, it certainly does not appear to be a silver bullet.

Although in several projects both the Swedish Transport Administration and the contractor appear to be very happy with how colocation has worked out, in others it left much to be desired. The main issue in these cases was the lack of a clear mandate for the Swedish Transport Administration's personnel to make decisions. In the projects where everyone appeared satisfied with the arrangement, the presence of knowledgeable project managers with a clear decision-making mandate seems to be the most important factor.

While Swedish Transport Administration project managers respond that they have executive authority and make decisions quickly, the contractors are almost unanimous in stating that, when it comes to making decisions, the Swedish Transport Administration is too slow. One project manager stated that a design-build contract requires more knowledgeable personnel at the Swedish Transport Administration and that it is very easy for them to pass on questions that they do not feel comfortable answering. This can leave some questions hanging for a long time. In some cases, the contractor does display some understanding of this, but generally speaking they are displeased and state that the long response times interfere with production, especially in railway projects where lost time working on the track is difficult to make up. Several respondents also highlight the fact that when the answer to the question may affect the budget, the response time is longer.

Another aspect, and one related to the issue of mandates and the Swedish Transport Administration as a pure purchasing organisation, is that many of the project managers are employed as consultants at the Swedish Transport Administration. Because of this, perhaps to a greater extent than the Swedish Transport Administration's in-house project managers, they seek approval for decisions higher up the hierarchy. A similar issue arises in smaller projects that the Swedish Transport Administration does not always staff with senior personnel. In these cases, while the Swedish Transport Administration maintains a presence, there is no one with decision-making authority.

4.3 Guidelines for innovation and experiences

Despite the push for design-build and the pure purchaser strategy to spur innovation, most respondents claim that the guidelines and rules issued by the Swedish Transport Administration remain an obstacle to innovation. This is especially clear in the case of the railway, where several respondents state that the purpose of the guidelines is not to encourage innovation but to keep maintenance costs in check. Some new guidelines and regulations have even had a negative effect on productivity by, for example, increasing safety margins at the expense of production speed. Several respondents raise the question of whether all guidelines and regulations are necessary in all cases and that the Swedish Transport Administration must drop some of them if the contractors are to be able to innovate.

Something that both the Swedish Transport Administration and the contractors agree on is that the length of time between a contract being awarded and building work beginning is crucial. The contractor needs time to design and test solutions and get them approved by the Swedish Transport Administration before work begins. Some respondents, both at the Swedish Transport Administration and contractors, bring up early involvement in the procurement process as a possible solution to this, although some recognise the issues this raises with regard to the Swedish Public Procurement Act (SFS 2016:1145).

Some project managers at the Swedish Transport Administration state that the higher risks carried by design-build contracts have caused contractors to innovate less, sticking to solutions they know will work and will not lead to additional expense. They argue that if design-build contracts are to result in more innovation, contractors must show more initiative. At the same time, some Swedish Transport Administration project managers state that they are unwilling to give contractors too much freedom as they feel that they lack the necessary experience and knowledge to perform the tasks unsupervised. Other project managers state that some contractors are very good and barely require any oversight. The contractors seem to have a slightly different perspective on this issue and stress that design-build contracts demand a great deal of knowledge from both themselves and the Swedish Transport Administration.

Some respondents raised the issue of the administration's new role as a pure purchasing organisation and the adverse effects this had had on production. Some contractors state that the new role has made Swedish Transport Administration project managers more interested in contract fulfilment than the results, as well as reducing cooperation. To some extent, this sentiment is reflected in the answers from Swedish Transport Administration project managers, who sometimes state that their new role is very different from their old one and that at times they feel less like project managers and more like contract managers – a feeling not far from the intentions of the reform.

Project managers from both the contractors and the Swedish Transport Administration agree that they are not sufficiently good at sharing and disseminating knowledge and experiences, whether between each other or between projects. While this learning deficiency is not unique to design-build contracts, the detachment from the project caused by the pure purchasing strategy is raised as one explanation as to why the problem is perceived as worsening.

One final insight shared by the Swedish Transport Administration's project managers, contractors and consultants alike is that not all projects are suited to design-build contracts. This view is particularly prominent among contractors and consultants, who reason that factors such as the road or rail planning process and guidelines on railway components leave the contractor with so little flexibility that shifting the risk from the Swedish Transport Administration to the contractor is likely to wipe out any potential profit.

5. Discussion

There appear to be several factors that have hindered the successful implementation of productivity-enhancing measures. While the Swedish Transport Administration's new identity as a pure purchasing organisation seems to have been rather successfully implemented (even if the impact on productivity remains unclear), the implementation of design-build contracts seems to have been far less successful. In the following five sub-sections, we will discuss possible explanations for this as well as potential remedies.

5.1 The organisation of Swedish planning

It takes a long time to build a road or railway in Sweden; more specifically, planning takes a long time. The planning process typically involves a needs assessment, consultation with the public and other stakeholders generating several alternatives, and then further consultation before a road or railway plan is established (Tornberg & Odhage 2018). Only then can construction begin. Given that the finished product is defined before construction commences, opportunities to achieve product innovation are limited.

The Swedish Transport Administration is the government agency tasked with long-term infrastructure planning, including roads and railways, in consultation with the public and local authorities. Involving contractors in the planning process before this consultation process is completed and a decision is made would in many ways threaten the integrity of the process. Of course, once the decision is final, the degree of flexibility in the contract is necessarily limited.

While this may well have a negative impact on innovation, there are clearly benefits to excluding special interests such as contractors from the planning process. The contractor could, for example, lobby for a more expensive solution, or one that makes it more difficult for competitors to tender for subsequent contracts. In their study of early contractor involvement (ECI) in Dutch infrastructure development, Lenferink et al. (2012) examine the same issue from another perspective: in influencing a public planning process in order to gain an advantage in a future procurement process, might the contractor be forced to give away information regarding its specific solution? And would this disincentivise meaningful participation in the planning process? This raises uncertainty regarding whether ECI is either desirable or feasible.

5.2 Regulation and components

The planning process is far from the only factor limiting the degree of freedom afforded to contractors. They are also restricted to using methods and components approved by the Swedish Transport Administration. This is a particular constraint in railway projects, which typically use more components than road projects.

In many cases, railway projects also involve trackwork on operating railway lines, further limiting flexibility. Working on or beside tracks requires the reallocation of track capacity from passenger and freight services to construction (or maintenance) work. Applying for capacity is a complicated process that begins long in advance, often before contracts are put out to tender. As the Swedish Transport Administration is responsible for applying for capacity on behalf of the contractor, the contractor may find itself limited not only by available capacity but even by how the administration assesses their likely needs. The timeslots eventually allocated to the contractor will restrict when and how the work can be performed. In interviews, the contractors state that this process may be too complicated for them to manage themselves.

The length of time between applying for capacity and beginning work is not deemed to be a problem in itself, as many contractors state that they are only too happy to have more time between the award of the contract and starting work. Finding the right balance between allocating capacity for train

services and allowing time for innovation in construction and maintenance is thus perhaps best left to the Swedish Transport Administration.

The Swedish Transport Administration has recently begun experimenting with cost-benefit analyses of various methods for performing track maintenance and reinvestment (WSP 2015, Lidén & Joborn 2016); however, in order to provide the contractors with the necessary track capacity to innovate, they must understand the contractors' methods. While this might not be an issue at present, the transition to a pure purchasing organisation has led to a skill drain from other areas of the administration (Witzell 2019). Torstensson et al. (2020) show that there is growing gap between the demand for and supply of qualified personnel at the Swedish Transport Administration, contractors and consultancies. It is reasonable to assume that this will hamper the administration's ability to provide contractors with fertile ground for innovation, as well as the ability of contractors to sew the seeds of innovation when the opportunity does arise.

Another limiting factor is the regulations issued by the Swedish Transport Administration specifying which methods and materials can be used in its projects. The interviews reveal that, while there are instances where new methods and materials have been used in road construction, such innovation is unheard of in railway projects. The Swedish Transport Administration is very reluctant to introduce new components, possibly for good reason. There is a misalignment of incentives to use new components and the Swedish Transport Administration's reluctance is protecting it from the potentially detrimental effects of new components. While new components may lower construction costs and increase the contractor's profit, even if they are as good as the old ones they may increase maintenance costs in the long term, as the Swedish Transport Administration will need to keep more spare parts in stock, thus driving costs. Economies of scale are achieved by reducing the number of different components.

Stricter safety regulations for working on or beside tracks are also hampering productivity in railway construction. While this is not directly linked to the introduction of design-build contracts, it does further restrict the contractor's freedom. One respondent stated that stricter safety regulations introduced over the past 10–15 years have both increased the time between the start of a shift and trackwork commencing and reduced the speed with which work can be performed. As with components, it is not difficult to see the rationale behind the Swedish Transport Administration's position: the construction sector suffers more fatal accidents than any other in Sweden (Swedish Work Environment Authority 2021).

5.3 Uncertainty in the role of a purely purchasing project manager

The transition to a pure purchasing organisation was intended to improve and professionalise the Swedish Transport Administration in its public procurement role. While this may well have been achieved, it has had the side-effect of altering the role of the administration's project managers; having once played an active role in building projects, they are now primarily tasked with ensuring that contractors fulfil the contract. This change is also reflected in other areas of the Swedish Transport Administration (Witzell 2019). One project manager describes this as a shift from making sure the end product is as good as possible to ensuring that the contract is fulfilled. While this certainly seems to be in line with the intentions of the reform, it is less certain whether this has improved the innovative capabilities of the sector.

The transition seems to have been successfully implemented in the sense that project managers have embraced their new role. That said, both the project managers themselves and contractors appear to harbour some doubts about exactly what this is. The project managers are uncertain about how and when they are mandated to make executive decisions, while contractors are uncertain about what they can expect from the project managers and the purpose of the new role.

Although the intention has clearly been to limit the Swedish Transport Administration's influence over building projects in the hope that this will give contractors the freedom to innovate, success depends

on the administration's ability to provide contractors with a suitable environment in which to do so. Uncertainty about the new role could inhibit this environment. Ten years ago, the task of the project manager was to ensure that the end product was as good as possible and delivered on time and on budget; now, the task is to ensure that the contract is fulfilled. From the perspective of the Swedish Transport Administration as an organisation, the end remains the same but the means have changed. From the perspective of the project manager, they no longer manage the project, they manage the contract. Uncertainty about this new role has perhaps caused the project managers to be overly concerned with the contract and not concerned enough with the end product. The focus on contract fulfilment described in some of the interviews is unlikely to produce a fertile environment for innovation.

Artto et al. (2008) describe the relationship between project autonomy and stakeholder involvement and the strategies employed by projects to solve their task. They define the strategies used by project groups with little autonomy – as is the case when a project is tightly governed by a contract and the project manager lacks the ability to make independent decisions – as *obedient servant* and *flexible mediator*. They argue that if project autonomy is higher, project groups can take on the role of *independent innovator* to solve their task. Perhaps when the Swedish Transport Administration settles into its new role, project managers will be less uncertain and project autonomy will be comparatively higher, hopefully leading to more innovation. On an alternate development path, project managers will settle deeply into the role of *obedient servant* or *flexible mediator*.

The uncertainty and different manifestations of the new role might also be symptomatic of the role itself rather than because the role is new. While in some cases it may be perfectly rational to give the contractors more freedom, in others it may be rational to intervene and micromanage the contractors. If the contractor expresses a wish to test a new solution, the project manager should encourage this; however, if the solution proves to be a bad one, the project manager should intervene and put a stop to it, even if this is potentially at odds with their role within the purely purchasing Swedish Transport Administration. This may be perceived as contradictory by contractors, as well as causing uncertainty regarding the role of the project manager.

5.4 Competence and trust

The relationship between contractors and Swedish Transport Administration project managers is crucial to innovation. Although contractors are encouraged to propose new solutions, ultimately these must be approved by the project manager. There are several reasons why the project manager may refuse to approve a new solution; aside from the obvious one, that it is deemed a poor solution, they might not trust the contractor's ability to execute the solution. On the other hand, if a contractor doubts the project manager's competence to evaluate a solution, they are unlikely to propose it. Some contractors stated that this is the case, viewing it as a consequence of the Swedish Transport Administration's pure purchasing remit and its new breed of project manager, who they feel have little "hands-on" experience. Irrespective of why contractors' proposals are rejected, in the end it will discourage them from investing time and energy coming up with and suggesting innovative ideas. Instead, they will focus on minimising risk by using proven solutions. But if the contractor has faith in the project manager's ability to evaluate proposals, and if the project manager has faith in the contractor's ability to implement them, then innovation is possible. Without mutual trust, no new solutions will be proposed or implemented.

Lack of trust is clearly an obstacle to innovation. If the Swedish Transport Administration were less restrictive in approving contractor's proposals, contractors would come up with more new solutions. One significant problem with the current approach seems to be that project managers have no incentive to embrace innovation, which is often a calculated risk. If the project manager's sole task is contract fulfilment, innovation will only happen when a project is in trouble and they are forced to take risks. Of course, another possible course of action in such a situation is to pass decisions up the chain of command, thus avoiding responsibility (Brunsson 2007).

5.5 Summary of obstacles and remedies

In Table 2, the main obstacles to innovation discussed above are presented along with potential remedies and obstacles to the remedies. As is the case on the wider literature on barriers to industrialised construction methods, the obstacles are to an extent interlocking (Wuni & Shen 2020). The barriers identified in this study also closely resemble those identified by Larsson et al. (2014) in a similar study of the same organisation seven years prior to this study. The first three obstacles are of a structural character while the latter three are related more to work in the projects and the relationship between contractor and the Swedish Transport Administration.

Table 2 - summary of the main obstacles to innovation, potential remedies and their obstacles

	Obstacle to innovation	Remedy	Obstacle to remedy
1	Design is locked during the early stages of planning.	Involvement of contractors in the early stages of planning.	The early stages of planning are a democratic process during which contractor involvement may be inappropriate.
2	Swedish Transport Administration approved components.	Easier to approve new components, especially in railway projects.	A larger heterogeneity of components drives maintenance costs.
3	Safety and environmental regulations limit the number of possible methods.	Loosen regulation.	Safety and environment are considered priorities for the Swedish Transport Administration.
4	Less opportunity for experienced project managers to steer projects in the new role.	Allow for a more active and proactive project manager role.	Concerns that a more active project manager could stifle contractor innovation. At odds with the vision of the purely purchasing Swedish Transport Administration.
5	Perceived lack of know-how among project manager limits their ability to understand and approve new solutions.	Improve the know-how of project managers and their teams. Provide incentives to innovate.	Does not fit the role of purely purchasing Swedish Transport Administration.
6	Perceived lack of know-how among contractors limits their ability to come up with new solutions.	Allow for mistakes in production and make contractors bear the risk.	Might worsen competition by eliminating smaller contractors without the resources to bear the risk.

Provide incentives to
innovate.

To a large extent, the first three obstacles are entirely reasonable: it makes sense to prevent contractors from interfering with the democratic process; it makes sense to restrict the number of different components to keep maintenance costs low; and it makes sense to strictly regulate a hazardous industry with the potential to damage the environment. Implementing remedies to these obstacles are thus not necessarily desirable for reasons other than productivity and the remedies for these are, arguably, less likely to be implemented.

The results are in many ways similar to the experiences from the use of incentives in public transport tendering. The past 30 years, most public transport in Sweden have been tendered to contractors. After the initial increase in productivity (Alexandersson et al. 1998) productivity increase has been low, and costs have risen (Vigren 2016). Public transport shares some characteristics with infrastructure construction in that there are significant restrictions on how the contractor can influence supply. To improve productivity, contracts with incentives have been introduced, in Sweden and abroad. The results from these contracts are mixed. In some cases, contracts with incentives have performed better than those without in terms of costs and quality indicators but not in terms of number of passengers (Pyddoke & Lindgren 2018). A study on the Scania region also does not show an association between incentive contracts and the number of passengers (Vigren & Pyddoke 2020). The authors highlight that a possible explanation could be that the conflict within the Public Transport Authorities (PTA), between the social responsibility and the need to improve productivity, could lead to PTAs refraining from providing the contractors with enough degrees of freedom to improve productivity.

There are potential remedies to obstacles 4–6. The remedy to obstacle No. 4 is to, at least to some extent, revert to the old style of project management. Whether this will lead to increased innovation is open to doubt, given that both the Swedish Transport Administration and external experts (SOU 2012:39) identified issues with the previous model. Both obstacle number 5 and 6 could be seen as expressions of the predictions in section 2.4. Since it is risky, and potentially costly to innovate project managers are reluctant to do so if they think that infrastructure output will suffer. Introduction of incentives to innovate could potentially help remove, or alleviate, these obstacles. In the case of obstacle No. 5, there are at least two ways to alleviate the lack of know-how among project managers as perceived by the contractors: i) improve their technical knowledge and ii) increase their willingness to take risks. While the first might seem like the obvious answer, this is at odds with the vision of the purely purchasing Swedish Transport Administration. One thing that appears to favour this solution is that the Swedish Government has appointed a commission of inquiry into how responsibility for basic railway maintenance can be transferred back from the state-owned company Infranord to the Swedish Transport Administration (Dir. 2018:24). Although the privatisation of track maintenance seems to have had a positive effect on productivity (Odolinski & Smith 2016), such a reform would increase the technical know-how of the Swedish Transport Administration. The second remedy, to increase the willingness of project managers to take risks, could be rephrased as increasing their willingness to trust in the solutions proposed by contractors. Currently, the obstacle to this is that there are no clear incentives for project managers to take more risks, given that their primary concern is contract fulfilment.

Obstacle No. 6 is the mirror image of No. 5, reflecting project managers' lack of faith in the ability of contractors to come up with reliable solutions. The finding that the lack of trust is impairing innovation should be seen in light of those of Boyne (1998), that competition for public contracts risks eroding the trust between contractors and the public. However, whether the lack of trust is a result of the tendering itself or a result of the type of tendering used by the STA is unknown. Since many of the

interviewees state that contracts presented as design-build are simply design-bid-build by another name, it seems plausible that the newspeak used by the STA is not exactly trust enhancing. However, it also seems possible that overhauling the contracts might create more opportunities to try innovative solutions. Shifting liability for the consequence of bad design to the contractor may reassure project managers about the quality of proposed solutions and make them more inclined to take risks with innovative designs. On the downside, this may place a burden of risk on contractors that, while manageable for large companies, may be prohibitive for smaller contractors. This could cause problems for the Swedish Transport Administration as smaller companies refrain from tendering for contracts, limiting competition and driving up prices. The Swedish Transport Administration could also be negatively impacted if, having been awarded a contract, a smaller contractor implements a riskier solution that fails after a few years and they are unable to meet the cost of fulfilling the warranty, leading to bankruptcy. This risk could be particularly high when dealing with less reputable companies.

While there seems to be little to be done about obstacles 1–3, there does appear to be scope for removing or at least circumventing obstacles 4–6. One potential strategy for success would appear to be to find a project with a sufficiently large degree of freedom to avoid obstacle No. 1, with few enough components to avoid obstacle No. 2, and far enough away from other activities to limit the effects of obstacle No. 3. In such a project, the right project manager and a good contractor should be able to build a relationship that provides fertile soil for innovation. The innovations from a successful project could then be transferred to other projects with less fertile conditions.

6. Conclusions

Reading the Swedish Transport Administration's own documents, one has a strong sense that the administration is trying to improve its productivity through innovation (Swedish Transport Administration 2019) and yet, because of the issues we have discussed, innovation seems to be very difficult to accomplish using the design-build contracts currently in use. Any productivity gains related to design-build seem to be the result of fine-tuning or other more direct productivity measures rather than innovation. As Skinner (1986) points out, it is very difficult to achieve innovation at the same time as increased productivity. He argues that direct productivity improvement is an effect of risk minimisation and fine-tuning: innovation is risk-taking. As we discussed in section 2.4 project managers have very little incentive to take risks. It thus appears as if any potential productivity gains from the Swedish Transport Administration's design-build contracts could be achieved using design-bid-build contracts.

The main obstacle to innovation appears to be that contractors are overly constrained. As summarised in Section 5.5, these restrictions differ in nature but are similar at the time of this study as at the time of a similar study by Larsson et al (2014), conducted seven years prior to this. Some are a consequence of the Swedish planning process, some of fears about the potential impact on maintenance costs, some of regulation. Finally, some seem to be a consequence of how project managers behave in their new role as "contract" managers in the pure purchasing organisation of the Swedish Transport Administration and in their relationships with contractors. While it may be difficult, or even undesirable, to do anything about the first three points, there are ways in which the project managers could change their behaviour to nurture a less restrictive, more innovative, environment. Even if it is very difficult to make project managers take risks, a less restrictive environment may facilitate diffusion of existing innovations.

There are two main ways of creating a more innovative environment. Firstly, by increasing the willingness of project managers to take risks and incentivising them to embrace innovative solutions proposed by contractors, even if they do not immediately appear to be improvements on current practice. This hinges on identifying a successful strategy for encouraging project managers to take risks. Even then, the Swedish Transport Administration must regain the trust of contractors so that they are willing to invest in developing innovative solutions.

One way of increasing the willingness of project managers to take risks might be to increase penalties and the scope of warranties. This would increase incentives for contractors to come up with reliable solutions and encourage project managers to accept them. The drawback is that this would shift the burden of risk towards the contractor to an even greater extent than current design-build contracts, potentially discouraging them from tendering for contracts.

The other way of making innovation more attractive is to create the perfect environment, with an experienced project manager mandated to try innovative solutions in combination with a skilled contractor. In such a situation, it should be relatively easy to establish the requisite trust between the project manager and the contractor to encourage the contractor to both propose innovative solutions and implement them. These can then be transferred to other projects.

Something that is important when attempting to create this “perfect” environment is to select the right project – a project that allows for creativity. The conclusion to be drawn from the Swedish experience appears to be that not all projects are suited to design-build contracts. A project that is largely free of restrictions imposed by earlier planning decisions might therefore be a good place to test the potential of such an environment, perhaps one involving bridges. As pointed out by Eriksson et al. (2019), time appears to be an important factor when fostering a successful collaborative environment, as such larger projects than the ones in this study are likely more suited to foster innovation.

The main lesson to be taken from this study is that the design-build contracts awarded by the Swedish Transport Administration are not silver bullets that guarantee innovation in the construction industry. For them to facilitate innovation they have to be paired with incentives for project managers to innovate or experiment, this is an important policy implication and something that other actors should take into account when attempting to spur innovation through the use of DB-contracts. It is worth noting that there are several fundamental differences between design-build as it is applied in private-sector construction and the Swedish Transport Administration’s design-build contracts, which significantly limit the freedom of the contractor. The Swedish Transport Administration has also failed to nurture the necessary environment to ensure that their design-build contracts fulfil their function of driving innovation. Creating such an environment and providing the necessary incentives is as important as the contracts themselves.

7. References

- Alexandersson, G., Hultén, S. & Fölster, S. (1998). The Effects of Competition in Swedish Local Bus Services. *Journal of Transport Economics and Policy* 32 (2), 203-219.
- Brunsson, N. (2007). *The Consequences of Decision-Making*. Oxford University Press: Oxford.
- Cachia, M. & Millward, L. (2011). The telephone medium and semi-structured interviews: a complementary fit. *Qualitative Research in Organizations and Management: An International Journal* 6 (3), 265-277.
- de Valence, G. (2010). Innovation, Procurement and Construction Industry Development. *Australasian Journal of Construction Economics and Building* 10 (4), 50-59.
- Dir. 2008:90, Commission of inquiry terms of reference: Översyn av myndigheter och verksamheter inom transportområdet. Available: https://www.riksdagen.se/sv/dokument-lagar/dokument/kommittedirektiv/oversyn-av-myndigheter-och-verksamheter-inom_GWB190 [2019-02-25]
- Dir. 2008:24, Commission of inquiry terms of reference: Överförande av basunderhåll från Infranord AB till Trafikverket. Available: <https://www.regeringen.se/496bc6/contentassets/8b8dbf2754314055b6701095e532c60f/kommittedirektiv-2018-24.pdf> [2019-08-23]
- Eriksson, P. E., Volker, L., Kadefors, A., Lingegård, S., Larsson, J. & Rosander L. (2019). Collaborative procurement strategies for infrastructure projects: a multiple-case study. *Proceedings of Institution of Civil Engineers: Management, Procurement and Law* 172 (5), 197-205.
- Frey, B. (1993). Does monitoring increase work effort? The rivalry with trust and loyalty. *Economic Inquiry* 31, 663-670.
- Jin, X-H. & Zhang, G. (2011). Modelling optimal risk allocation in PPP projects using artificial neural networks. *International Journal of Project Management* 29, 591-603.
- Larsson, J., Eriksson, P. E., Olofsson, T. & Simonsson, P. (2014). Industrialized construction in the Swedish infrastructure sector: core elements and barriers. *Construction Management and Economics* 32 (1-2), 83-96.
- Lenferink, S., Arts, J., Tillerna, T., van Valkenburg, M. & Nijsten, R. (2012). Early contractor involvement in Dutch infrastructure development: Initial experiences with parallel procedures for planning and procurement. *Journal of Public Procurement* 12 (1), 4-42.
- Lidén T. & Joborn, M. (2016). Dimensioning windows for railway infrastructure maintenance: Cost efficiency versus traffic impact. *Journal of Trail Transport Planning & Management* 6 (1), 32-47.
- Migue, J. & Belanger, G. (1974). Toward a general theory of managerial discretion. *Public Choice* 17, 27-43.
- Nilsson, J-E., Nyström, J. & Salomonsson, J. (2020). Produktivitet i bygg och anläggningssektorn. VTI rapport 1049.
- Niskanen, W. (1968). The Peculiar Economics of Bureacracy. *American Economic Review* 58 (2), 293-305.

- Nyström, J., Nilsson, J.-E. & Lind, H. (2016). Degrees of freedom and innovations in construction contracts. *Transport Policy* 47, 119-126.
- Odolinski, K. & Smith, A. (2016). Assessing the Cost Impact of Competitive Tendering in Rail Infrastructure Maintenance Services: Evidence from the Swedish Reforms (1999-2011). *Journal of Transport Economics and Policy* 50 (1), 93-112.
- Pyddoke, R. & Lindgren, H. (2018). Outcomes from new contracts with “strong” incentives for increasing ridership in bus transport in Stockholm. *Research in Transportation Economics* 69, 197-206.
- SFS 2010:185. *Förordning (2010:185) med instruktion för Trafikverket*. Stockholm: Ministry of Infrastructure.
- Shrestha, P., O’Connor, J. & Gibson, E. (2012). Performance Comparison of Large Design-Build and Design-Bid-Build Highway Projects. *Journal of Construction Engineering and Management*, 1-13.
- Skinner, W. (1986), The productivity paradox. *Harvard Business Review* 64, 55–59.
- Swedish Work Environment Authority (2021). Dödsolycka i arbete. Available: <https://www.av.se/globalassets/filer/statistik/dodsolyckor/arbetsmiljostatistik-dodsolyckor-i-arbetenaringsgren-2011-2020.pdf> [2021-09-30]
- Syverson, C. (2011). What Determines Productivity? *Journal of Economic Literature* 49 (2), 326-365.
- Productivity Commission (2012). *Vägar till förbättrad produktivitet och innovationsgrad i anläggningsbranschen (SOU 2012:39)*. Stockholm: Ministry of Enterprise and Innovation.
- Tornberg, P. & Odhage, J. (2018). Making transport planning more collaborative? The case of Strategic Choice of Measures in Swedish transport planning. *Transportation Research Part A: Policy and Practice* 118, 416-429.
- Torstensson, P., Hedström, R., Svanberg, L. & Sedehi Zadeh, N. (2020). Prognos över framtida kompetens- och resursbehov knutet till svensk infrastruktur för spårburen trafik: Delrapport 3 av 3 i projektet ”Prognosmodell för framtida kompetens och resursbehov knutet till svensk infrastruktur för spårburen trafik. VTI rapport 1035. Linköping: Swedish National Road and Transport Research Institute (VTI).
- Swedish Transport Administration (2019). *Trafikverkets arbete med produktivitet och innovation i anläggningsbranschen*. Swedish Transport Administration: Borlänge.
- Transport Analysis (2017). *Trafikverkets arbete för ökad produktivitet och innovation i anläggningsbranschen: Slutrapport. Rapport 2017:5*. Traffic Analysis: Stockholm.
- Vigren, A. (2016). Cost efficiency in Swedish public transport. *Research in Transportation Economics* 59, 123-132.
- Vigren, A. & Pyddoke, R. (2020). The impact of bus ridership of passenger incentive contracts in public transport. *Transportation Research Part A: Policy and Practice* 135, 144-159.
- Wani, Y. I. & Shen, Q. G. (2020). Barriers to the adoption of modular integrated construction: Systematic review and meta-analysis, integrated conceptual framework, and strategies. *Journal of Cleaner Production* 249 (10), 119347.
- Williamson, O. (1975). *Markets and hierarchies: analysis and antitrust implications*. New York: The Free Press.

Witzell, J. (2019). Physical planning in an era of marketization: confliction governance perspectives in the Swedish Transport Administration. *European Planning Studies* 27(7), 1413-1431.

WSP (2015). Metod för samhällsekonomisk utvärdering av banarbeten. WSP Rapport

WSP (2017). Trafikverkets produktivtetsarbete i praktiken – underlagsrapport. WSP Analys och Strategi.

Österberg, E. E. and Qvist, M. (2018). Public Sector Innovation as Governance Reform: A Comparative Analysis of Competitive and Collaborative Strategies in the Swedish Transport Sector. *Administration & Society*. doi: 10.1177/0095399718789077.

8. Appendix 1 – interview questions

The questions posed in the interviews were structured around three themes listed along with the questions below.

Tendering and design

- 1) It is your perception that the contractor's commitments were defined as functional specifications (DB) or design specifications (DBB)?
- 2) Does the contract depart from the industry's standard contract? How has it affected the execution of the contract?
- 3) In what ways were the contractor able to influence the design of the contract in the tendering phase (e.g., solutions, materials)?
- 4) Were basic conditions (such as geotechnical conditions) clearly presented in a manner which the contractor could use as basis for their tender? How has this affected the tender?

Organisation and construction

- 5) Describe how cooperation (e.g., communication, meetings) between the STA and the contractors was organised. How has this affected execution?
- 6) To what extent has the organisation been able to make quick decisions when required?

Post-construction reflections

- 7) Has the executed contract lived up to the specifications and expectations of the STA?
- 8) How are lessons learned from the contract absorbed into the participating parties and what routines are in place in order to pass those lessons on to other contracts?
- 9) In your experience, to what extent are the STA's rules and routines designed in ways to stimulate contractors to seek more effective solutions?
- 10) Based on your experience, if you could give a message to the STA about its measures to improve efficiency, what would it be?

- The STA attempts to improve innovation through the implementation of DB-contracts
- Contractor and STA project managers state that there are multiple barriers to innovation
- Some barriers are legitimate, and some could be overcome with the correct measures
- The most important measure would be incentives for project managers to experiment

Conflict of interest

None

Anders Bondemark: Conceptualization, Methodology, Data Curation, Writing - Original Draft, Writing - Review & Editing, Funding acquisition

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