Integrated Product Service Offerings for Rail Infrastructure - Benefits and challenges regarding resource efficiency and knowledge transfer

Sofia Lingegård and Mattias Lindahl
Department of Management and Engineering, Linköping University,
Linköping, Sweden

Large amounts of material are used for rail infrastructure causing significant environmental impact. At the same time the industry's motivation to innovate is low and the lowest price is the main driver for selecting a tender. The concept of Integrated Product Service Offerings (IPSO), have in several business areas proven to be a mean with potential to reduce the environmental impact of products and services, increase cost efficiency and quality, and act as a driver for change. The business model is based on a life cycle approach and focuses on the function and not the product of an offering.

The objective of this paper is therefore to *investigate the potential benefits and challenges regarding resource efficiency and knowledge transfer from the provider and buyer perspectives when using IPSO for rail infrastructure.* In order to this, theories such as resource efficiency, product development, knowledge transfer, networks and literatures focusing on IPSO are used to discuss the empirical findings. The empirical part has been collected using individual interviews and a focus group approach.

Among the main findings is that fact that the lack of information transfer and knowledge integration is a barrier for innovation and the buyer's conservative business culture makes it difficult to implement new types of contracts. Since IPSO contracts require improved information transfer they could potentially stimulate innovation as well as processes for evaluation of the contracts. IPSO contracts provides a holistic life-cycle perspective and incentives for dematerialization, resulting in a more resource-efficient and durable infrastructure. By involving the contractors already in the design phase their knowledge could be used in a better way, creating a feedback loop from practice to design. The contractors hope that by introducing IPSO contracts the buyer would focus less on the initial purchasing price and more on the total life-cycle cost in relation to quality in order to get the best solution.

Several challenges with IPSO are discussed, and most of them are derived from the risk and uncertainty aspects that come with long-term contracts and inexperience with a new business model. New competences in risk management and other types of calculation methods are needed but most of all a change in mindset. Some of these uncertainties also are connected to the inadequate documentation hindering IPSO contract working for anything but new investments.

Key words: Rail infrastructure, Long-term contracts, Supplier-buyer relationships, Knowledge transfer

1 Introduction

Building and maintaining rail infrastructure requires large amounts of materials, and the environmental impacts from the upstream production stages are significant (Svensson and Eklund, 2007). Thus far, the Swedish Transport Administration (STA) has not had a life-cycle approach to its work. There is a need for the STA to start working with the environmental management of products when designing new products, i.e. before introducing them in the material supply chain, to reduce their environmental impacts (Svensson, 2006).

Certain contracting forms, such as performance contracting, can increase the drivers for change within the industry and thereby increase cost efficiency and quality from a life-cycle perspective (Statskontoret, 2009). The fact that the provider has control over the whole life-cycle of the product provides incentives to realize more environmentally and economically sound development when considering the whole life-cycle (Lindahl et al., 2009). This type of contracting is also known as an Integrated Product Service Offering (IPSO), and implies that one actor has the responsibility to deliver a result and therefore has incentives to optimize the use of energy and material. This, implies that the provider needs to be in charge of the design phase since it is in there where materials are selected and most of the environmental impacts are set (Lewis and Gertsakis, 2001).

The railway industry is characterized by low productivity development, low motivation to innovate, a rare use of new products and methods as the lowest price being the main driver for selecting a tender (Nilsson, 2009a; Olander et al., 2010). Mismanagement of the rail infrastructure over the past decades has caused poorly maintained infrastructure and an inefficient organization (Alexandersson and Hultén, 2008; Thompson et al., 1998; Tullberg, 2000).

The need for change and development is known within the industry; in 2003, STA initialized the Renewal in the Civil Engineering Industry forum, with the purpose of creating a forum for renewal (FIA, 2011). Greater efficiency, improved interaction, better incentives for research investments and more effective mediation of knowledge are the established goals for this initiative, and terms like ”life-cycle thinking“ and “improve resource efficiency“ are mentioned as ways to reach these goals (FIA, 2011).

Since IPSO contracts could be one way to achieve this, by introducing the industry to life-cycle thinking and performance contracts, the aim is to *investigate the potential benefits and challenges regarding resource efficiency and knowledge transfer from the provider and buyer perspectives when using IPSO for rail infrastructure.*

2 Methodology

This paper has an exploratory nature, since IPSO contracts are not commonly used in rail infrastructure and little has been published in this area. The main empirical data is collected using qualitative interviews and a focus group.

The choice of respondents was made to get the overall picture of the industry and to gain knowledge of both the buyer and the providers' perspectives and their interaction. In total, the results from 14 interviews are included, seven from STA and seven from the main contractors. Both phone interviews and face-to-face interviews were performed, and all were recorded.

Thereafter, a five hours focus group was realized, with three managerial STA respondents from the interview study, in order to trigger a discussion of the results from the interviews.

3 A life-cycle perspective for product development

Since railway infrastructure is responsible for large environmental impacts, it is interesting to look into proactive ways to improve future construction and maintenance work. A strategy to reduce material and energy is dematerialization, where the focus is on lowering the inputs (Dobers and Wolff, 1999), and focusing on dematerialization can reduce the environmental impact (Mont, 2000).

Dematerialization contributes to lowering environmental impacts as well as to reducing costs, and key factors are e.g. cooperation and a focus on functions, and not on products (Dobers and Wolff, 1999).

Previous research within the infrastructure industry states that the earlier in the planning process the provider is involved, the better the opportunities are to adapt the content and the realization of the project to its specific conditions and the requirements (Nilsson, 2009a). The importance of making decisions early in the product development process, when there is still freedom to make changes has been stated in earlier research (Lindahl, 2005). The further along in the process the more modifications cost, due to the difficulty in making the changes.

The management of the activities involved in the process of idea generation, technology development, manufacturing and marketing of a new or improved process or product can be described as innovation (Trott, 2012). Innovation could be improvements of a product or something new to the world or the firm (Ahmed and Shepard, 2010). The performance of a technology is often displayed in a S-curve where the performance is plotted against time or engineering effort (Christensen, 1992). In the beginning of the curve differentiation of design is in focus for the market, followed by a standardization phase where a dominant design is set (Trott, 2012). This is when the focus shifts to efficiency and lowering production costs (Schilling and Esmundo, 2009). It is here where the bargaining power for both supplier and customer will increase and the actors will secure positions on the market, providing entry barriers for new actors (Trott, 2012). The dominant design is not always the best or optimal technology, but could instead be the design that has a faster learning curve; the result is that the more learning that occurs, the less likely the actors will be to investigate other technologies, even if they are better (Ahmed and Shepard, 2010).

Technological lock-in is a result of mainly two elements; technological paradigms, i.e. technology S-curves, and increasing returns to adoption, meaning incentive structures and reinforcement paths for a technology (Perkins, 2003)). Technologies are parts of broader networks with supporting infrastructures with physical evidence along with technical, economic and organizational structures enabling existing technologies (Perkins, 2003). Learning, culture and habit can lead to inefficiency due to employees' unwillingness to explore new ways of doing things, since this could cause them to lose their positions of control and power (Ahmed and Shepard, 2010). The costs for switching a technology becomes significant, since not only physical elements need to be changed but also existing skills, behavior patterns and work practices (Perkins, 2003). It is also true for customers that become attached to products even though there are better or cheaper options (Ahmed and Shepard, 2010). These network factors raise the barriers for new technologies that are not part of the dominant technological design to enter the market (Perkins, 2003). The result is a type of market lock-in. For the rail infrastructure market and technology, lock-ins are e.g. the width of the tracks and the signal system that need to be compatible with the trains. Another market lock-in is the situation where there is only one dominant buyer on the market, as is the case for rail infrastructure in Sweden.

3.1 Introduction to Integrated Product Service Offerings

Business models that include the life-cycle approach and emphasize the integrated development of the product and the service for the offering are called Integrated Product Service Offerings (IPSO) (Lindahl et al., 2009; Meier et al., 2010). IPSO has a life-cycle perspective and includes large parts of the value chain in an integrated offering that instead of selling physical products provides functions, service and performance (Sundin, 2006). With integrated development, it is no longer possible to separate the product and the service in the different phases of the life-cycle (Meier et al., 2010).

IPSO provides the supplier with a possibility to increase the value of the solution for the customer by integrating components in new ways (Brady et al., 2005), and is thereby a driver for the development of technical solutions (Lindahl et al., 2009). There are incentives for the supplier to realize improved economic and environmental development when considering the whole life-cycle (Lindahl et al., 2009).

However, information is needed to do so, and it might not always be easily accessible. Between the provider and the user, information asymmetry is found in many cases (Lingegård et al., 2011). Briefly explained, the provider often holds more information about the product than the user. This could be information concerning toxicity of a product, or perhaps how to achieve the best energy performance. The reasons for this asymmetry could be diverse, such as a lack of user education or a deliberate strategy from the provider's side. Nevertheless, the information asymmetry could be a key factor in making IPSO a meaningful business model and the provider has the possibility to provide more efficient maintenance or upgrades during the use phase.

3.2 Developing an Integrated Product Service Offering

Infrastructure projects procured using integrated contracting including design, construction and maintenance have better life-cycle costs and are completed faster (Pakkala, 2002). Additionally, using a product-service mix with more durable materials and other designs may prolong the lifetime of the product and potentially optimize maintenance and operations (White et al., 1999).

In a mature market like the rail infrastructure industry it can be difficult for providers to differentiate due to standardized technology, which makes the competition focused on price and subsequently low profit margins (Mont, 2004). There are innovation possibilities since the offerings follow the customer's needs, but this requires a focus on the whole system with suppliers and buyers (Lindahl et al., 2009; Tukker, 2004). The knowledge that actors gain through experience provides leverage in the process of incremental innovation (Trott, 2012). A benefit mentioned in the literature for IPSO is the possibility to gain knowledge during the use of the offering to reconfigure or redesign it (Meier et al., 2010). Knowledge is a key issue when talking about production and innovation and previous research has shown that external sources of knowledge like suppliers and users can be very important for innovation (Malerba, 2002). Involving suppliers early in the product development process can provide designs more suitable for manufacturing and save later manufacturing costs (Chung and Kim, 2003). Apart from the saved cost, a reduced cycle time, improved quality and greater technological improvement are potential benefits from involving suppliers (Handfield et al., 1999). This is possible since the supplier could have greater experience with the technology providing a reason to integrate the supplier in the process (Handfield et al., 1999).

To become a service provider, considerable changes have to be made within the organization, capabilities and management of the firm. In fact, this change is considered one of the major barriers for the business model, as it leads to changes both within the organization as well as changes in the relationship with other actors in the product-service chain (Mont, 2002). One of the great challenges with IPSO is to manage the supply chain, which plays an important role for the business model (Meier et al., 2010; Mont, 2004). Uncertainties related to the supply chain include capacity, resource availability and capability in the supply chain network (Erkoyuncu et al., 2011). Conflicts of interest between the different actors in the supply chain can also be a challenge for IPSO (Mont, 2002). Another external barrier for IPSO could be the lack of demand from public procurement, which otherwise could serve as a driver (Mont, 2002).

IPSO implies taking over some of the customer's processes, which is a major risk for the provider (Meier et al., 2010). On the other hand, IPSO also reduces unpredictability and variability of demand during the contract time, which makes risk reduction a driver for the business model (Mont, 2004; Oliva and Kallenberg, 2003). Long-term contracts increase risks and uncertainty, and the risks are caused by uncertainties that for a long-term performance-based contract arise at the bidding stage (Erkoyuncu et al., 2011; Meier et al., 2010). The uncertainties and risks need to be identified, planned, assessed, handle and monitored, and the provider and customer should cooperate in doing so (Meier et al., 2010).

The transition to an IPSO business model imposes organizational challenges for both provider and buyer. Buyers might lack life-cycle cost knowledge needed to evaluate the offering and understand the concept due to a traditional business mindset (Mont, 2004). The new conditions require that operational and organizational structures for the provider need to be adapted (Meier et al., 2010). For instance, a cross-functional way of working to design an IPSO is a necessity, meaning that representatives from different areas and departments in the provider organization need to be involved (Brady et al., 2005). Since more information is needed, more trust is required between the buyer and supplier to achieve this transparency (Lingegård et al., 2010). IPSO also implies a longer business relationship that needs to be strong for long-term performance (Meier et al., 2010).

A challenge is the traditional mindset among customers (Alonso-Rasgado et al., 2004). Instead of focusing on the product price, the customers need to focus on the price for the whole life-cycle, and these two cannot be directly compared. The customer needs to learn about the cost structure of the offerings; otherwise, this lack of knowledge could serve as a barrier (Mont, 2002). There is, therefore, a need for models and tools that can illustrate in a simple way the financial benefits of the offers (Berggren and Björkman, 2002). Additionally, customer acceptance of the offering as well as trust between the actors is of importance (Mont, 2002).

4 Results related to the current situation

4.1 How rail infrastructure procurement works today

In traditional contracting, the life-cycle of the rail infrastructure is divided into several different contracts, with different actors involved in each phase. There is no continuation between building and maintaining since these are separate contracts and there could also be separate contractors who win the contract.

Construction contracts, or Design-Bid-Build contracts, where the procurer specifies what, how and how much, are the most common contracts within the infrastructure construction industry in Sweden (Nilsson and Pyddoke, 2007; Nilsson et al., 2006). Typically, the scope of the projects and the detailed design specifications are realized by consultants on behalf of the STA, and the contractor is obliged to realize the project within the set time, price and standard level (Pakkala, 2002). The choice of tender is mainly based on the lowest price (Hedström et al., 2005). Construction contracts imply that the procurer carries all the risk, and a maximum roof for the price is set which does not create any incentives for contractors to make the processes more efficient; instead, they benefit from reaching the maximum sum (Nilsson et al., 2005). A newer type of contracting for building rail infrastructure is the Design-Build contract, where the contractor is responsible for both the more detailed design phase as well as the construction phase (Nilsson, 2009b). This provides an opportunity for the contractor to influence the construction but has so far not been used to a large extend in Sweden.

Since 2005, performance contracts have been used for maintenance in Sweden, meaning that STA procures a set functionality of the track and the contractor decides appropriate measures to take while still considering maintenance regulations (Riksrevisonen, 2010). Performance contracts are similar to Design-Build contracts in that the contractor is responsible for parts of the detailed design. The function, however, is set on a detailed level, and is far from an overall function. The length of a performance contracts is five years, with an additional two-year option that usually falls out, and with bonuses and penalties used as a control mechanism. Several maintenance contracts are procured after each other during the life-cycle of the facility. Additionally, during the lifetime of the infrastructure reinvestments are needed to maintain the functionality of the infrastructure.

The STA is divided into two divisions, where the Investment Division participates in the Design and Construction phase, while the Traffic Division is involved in the Operations and Maintenance contracts. Contractors formulate tenders based on detailed specifications provided by STA, and the procurement of the construction and the subsequent operations and maintenance are done independently. Traditional contracting, and specifically construction contracting, has several advantages such as being a familiar business model which all actors can relate to and calculate. STA also emphasizes the fact that they know what they get, since the contract has been specified all the way to its end.

The current procurement practice is seen as resource-demanding from both sides. The procurement is seen as inefficient and an example is the design results that are delivered by consultants that are not optimal for actual building. These quality issues are noticed by the contractor during the building phase, and result in lost time and money when the design has to redone. However, sometimes these contracts end up looking a lot like construction contracts due to STA, which interferes in the contractor's work. It is similar for the maintenance contracts based on performance where the function is in construction technicalities, since the stretch, design and appearance are already set.

4.2 Modelling an IPSO contract

An IPSO contract for rail infrastructure can be described as a life cycle contract including design, construction and maintenance, se Figure 1. The outcome is measured in the performance of the facility. The functional requirements are set on a higher level than for the design-build and performance contracts currently used for maintenance. STA procures a function and does not specify in detail how the contractor should realize it, e.g. "build a railway from A to B with C capacity and maintain it for X years. After the contract period the railway should have Y required capacity." The initial planning of the stretch and the environmental evaluations would still be performed by STA since the phase includes e.g. redemption of house and environmental impact assessments that can make or break the approval and realization of the project. The design of the construction and the maintenance is the responsibility of the contractor. The design and construction phases in the IPSO contract depend on the scale of the project, while the operations and maintenance phase is estimated by the actors to run between 10-45 years.

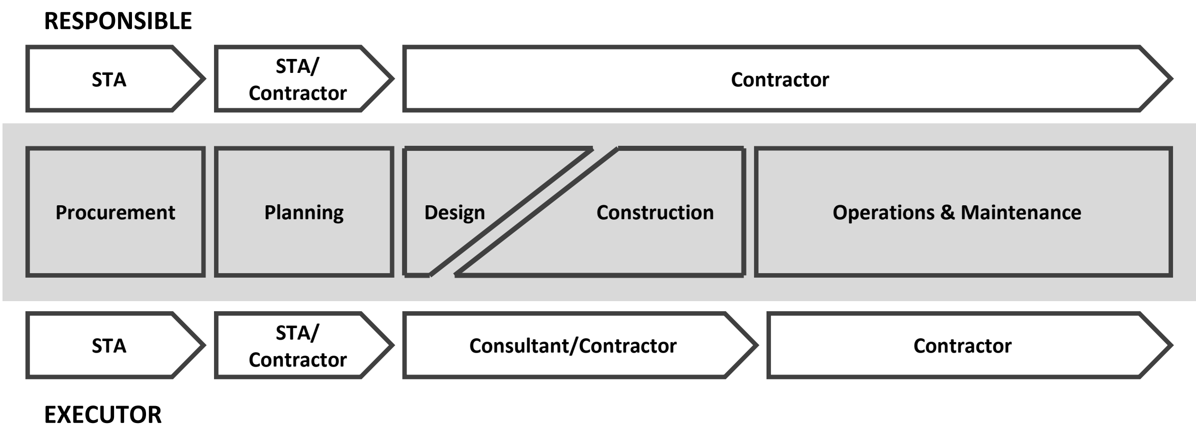

Figure 1: Schematic figure illustrating an IPSO contract for rail infrastructure (Lingegård, 2012).

5 Results related to IPSO offerings

5.1 Benefits with IPSO

According to contractors, extended responsibility compared to today is required for development. An increased contractor responsibility would start a thinking process making use of the knowledge within the organization. It was pointed out that the contractor would have to start thinking about where in the life-cycle you could make money and how. One of contractors claimed that everything lasts for five years, but with longer contracts they would be more thorough. It would be more interesting for a contractor to use solutions that lower the operations and maintenance costs and this could be done with solutions that are more durable and do not require many measures. It was stated by most of contractors that this would probably increase the lifetime of products.

In general, STA believes that the contractor would build more durably if they knew they were to maintain the infrastructure for a longer period as well. Some of the respondents also believe that contractors would probably control the design consultants in a better way than STA, which would save both time and energy compared with the current situation.

STA respondents think that the IPSO contract would provide more thought through construction in terms of maintenance. The holistic view would make contractors adopt a life-cycle perspective and consider the life-cycle costs of the infrastructure. The contracts would spur innovation development in the industry, since sufficiently skilled contractors would realize solutions providing a lower cost, which would result in a competitive advantage. This would be a driver for the whole industry to be innovative, but the development would start with small steps.

Contractors believe that from an organizational perspective, the benefits would be a smoother transition between the construction and the maintenance phase of the projects, as the knowledge is already within the organization. This knowledge could be used to discuss solutions in the organization, and ensure that no one takes shortcuts, since the contractor is responsible for the entire project. A long-term contract would provide long-term planning, making it easier to make investments due to the longer payback time. Finally, it was said that this could lead to less focus on the lowest price and instead the proposals with the best solutions could win the bidding.

5.2 Challenges for IPSO contracts

Contractual challenges – The length of an IPSO contract is important, but at the same time difficult to decide. According to STA it has to be long enough so that the contractor is forced to take the consequences in the maintenance phase for choices made during the design and construction phases. Also, it has to be long enough for the contractor to be able to make investments and build an organization around the project. Some STA respondents think that the contracts should last the entire economic lifetime of the infrastructure, but also add that this might not be possible since it would be too long. If the contracts were as long as the lifetime of the material this would not be a problem, but different materials have different lifetimes, and it would be difficult to find the point in time where it would be most efficient to end the contract. According to contractors, the longer the contracts are, the more durable the construction must be. If the contracts are too long, however, it will be difficult to calculate and there will be a charge for the risk, making it more expensive for the community and that is not the point with this type of contract. Other issues raised by contractors were the volume of the contract, the limits of the contracts relatively other surrounding contracts etc. Contractors believed that more transparency would be necessary as well as common goals for this type of contract to work.

STA believed that the procurement process would become longer, since it would take more time for contractors to calculate, and because the time for STA to evaluate the tenders would increase. They mentioned the difficulty in evaluating a long-term contract, because it takes many years to get the overall picture. In addition, the complexity of defining functional requirements for the contracts, setting appropriate measures as well as measuring the residual value of the infrastructure will be challenging. The concerns about the functional requirements and the measuring were shared by contractors.

The way in which the risk would be shared with the IPSO contracts was one of the main concerns contractors had, even though there were different opinions concerning how big of a challenge the increased risk taking was. The IPSO contract would give contractors more risk, but some of them also identified more opportunity, and as long as these two factors were in balance it would not be a problem. Re-negotiations during the course of the contract period were mentioned as a way to reduce the uncertainties. STA respondents agree that the partner with the best ability to affect the risk should be the one with the responsibility for it. For the IPSO contracts, contractors would take all the responsibility and thereby more risk, which they might compensate for with a higher price. According to STA, this increased risk-taking will have to be compensated for by intelligent solutions.

Market-related challenges – The size of the contracts, geographically and in terms of volume and content, is a concern for contractors. The contracts have to be large enough to create the volume needed for investments but the contractors are also concerned that too many larger contracts would result in a locking of the market, leaving some contractors outside for years. This would then decrease the competition, which is already low. An IPSO is a large project and thus requires a large contractor, which according to STA would exclude smaller organizations.

Furthermore, one contractor could not realize this type of contract by itself; there is a need for both a general contractor making the foundation and a technical contractor building the actual rail infrastructure and performing the maintenance. The question is which one should be the IPSO contractor. The respondents feel that it would be logical if the technical contractor had the overall responsibility, since that is where the technical competence is located. On the other hand, these companies are in general too small, and a larger general contractor is better suited to lead such a project. Even though the number of national contractors that would leave tenders for an IPSO contract would be reduced, the respondents think that the number of international contractors would increase, since an IPSO contract is large enough for them to invest in Sweden.

Contractors and the STA believe that IPSO contracts would only work for new large investments due to two reasons. First, contracts have to be large enough to be economically beneficial to build an organization around it and to make investments. Second, documentation is lacking for the older infrastructure, resulting in too many uncertainties concerning the condition of the material and components.

Organizational challenges – The IPSO contract is complex and none of contractors think they can handle all the parts within their own organization. They believe that companies will join forces, but the interface between them was identified as a difficulty. One contractor has to take the overall responsibility for the IPSO contract, as stated above.

Currently, contractors do not have design competence within their organizations. The contractors would probably use the same consultants as STA, but the majority of the respondents believe that the contractor would control the consultants better than STA. To be able to do this some contractors stated that they need to have a competence base in-house, while other believed that a development division of their own would be necessary to achieve real innovative solutions.

The long-term survival of contractors was also mentioned, and the technical contractor did not believe that long-term resources would be a problem if they had the responsibility, but it would be a different story for the general contractors that would be dependent on the technical resources from outside their organizations. Another issue mentioned by contractors related to the long-term perspective was that the interest within contractors' organization might disappear during the course of the contract, since the same people are not working in the organization during the entire period. This also relates to the continuity of IPSO projects that is needed on the market to maintain the competence within the organizations. One of contractors mentioned that the offering would probably not be immediately cheaper, since it takes time to learn.

The Investment Division and the Traffic Division at STA are two organizations that have little integration and very different ways of thinking. While the Investment Division has a project-oriented work form that follows an investment project, the work of the Traffic Division follows yearly cycles, i.e. fall-winter-spring-summer. Connecting these two divisions will not be done without friction, according to some respondents within the STA. Furthermore, STA respondents describe the organization as a technically-oriented with a business culture where the employees, in general, are very interested in all the technical details of the contracts. This fits perfectly with the construction contracts but another approach, where contractors take the responsibility, needs to be adopted to work with IPSO contracts. The respondents describe this change as a hurdle the STA must pass.

Competence is another area that was mentioned by STA respondents, and some stated that having people bound to long-term contracts would result in a lack of competence in an industry that already has a shortage of competence in some areas. More competence in calculation and risk management is needed within contractors' organization. Concerning the competence within STA, the respondents seem to agree that most of it already exists and that the major challenge is coordination, e.g. the cooperation between the Investment and Traffic Divisions. The importance of improving documentation, however, is emphasized. This is needed since the people procuring an IPSO will probably not be there during the entire course of the contract.

An additional organizational concern among STA respondents is the relationship with contractors. Another type of relationship is needed that is built on more trust than found in the current relationships. This is needed since contractors will take over much of the responsibility that STA has today, and STA will have to take a step back. According to several of the respondents, however, this will be difficult due to the business culture at STA. STA respondents still feel that some type of follow-up is needed of the IPSO contracts, since everything cannot be assigned to the legal framework and the regulations.

There are different opinions among contractors concerning the competence and readiness of STA. The IPSO contract is another business model and requires a new way of thinking; this part was seen as the most difficult for STA. Most of contractors do not believe that STA is prepared for the price of the contracts, and doubt the organization can evaluate the bids while other state that STA has the competence but it needs to be communicated and more interaction is needed within the organization.

6 Discussion

The traditional construction contracts have advantages such as being a familiar business model that is straightforward to calculate for contractors. This is in line with previous research that states that an advantage with construction contracts is that the distinct roles of the buyer and contractors are clear (Pakkala, 2002). The STA knows exactly what will be built, but on the other hand the STA does not get more than asked for since the contractor only are paid to follow the specifications. Detailed specifications do not optimize the innovation since innovation typically comes through the contractor or supplier network (Pakkala, 2002).

6.1 Technological lock-in and lack of information transfer

In the rail infrastructure industry a dominant design for contracts has reached standardization and a focus on the lowest price. The focus in the standardization phase of a technology cycle should also be on efficiency (Schilling and Esmundo, 2009), which is not the case for the rail industry.

Currently the only actor that has the overall view and responsibility of a railway facility is the STA. This means that STA should hold information concerning the condition of the rail infrastructure. However, today’s information lacks details and is not complete; contractors have no incitements to provide data from their operation. Gained knowledge is not transferred back to STA and the design consultants when they design projects. It exist an information asymmetry between contractors and STA and the consultants. Design and performance of a system can be improved by using knowledge about the system performance (Geyer and Davies, 2000), but in this case this feedback loop is lacking. This results in wasted time and increased costs while the design is re-worked, which can be compared to the design paradox where product knowledge increases with time in the product life-cycle and modification costs increases cf. Lindahl (2005). This is an example of the cost overruns that are usual for this type of contracting (Pakkala, 2002). Previous research states that construction firms do not fully use their experience due to lack of time or incentives to develop and capture it (Reichstein et al., 2008). This means that the next contract starts with the same information level as the previous one both for construction contracts and maintenance contracts.

The information could potentially result in efficiency gains and technical development, since it is in the design phase the major decisions are taken (Lewis and Gertsakis, 2001). The technology and design is locked for the whole life-cycle of the facility, when it has been realized but there is on the other hand room for incremental innovation (Christensen, 2000). This will however only be possible if the information concerning failures and possible improvements is transferred back to STA and incorporated into the design. The same standards are chosen repeatedly since there are no feedback loops bringing back information that challenges the current technology and standards. This is an example of how the existing structures such as behavior patterns and work practice are enabling and reinforcing the existing technology (Perkins, 2003).

6.2 Developing a more durable railway

An IPSO with a fixed price could provide incentives for minimum input and maximum utilization of the elements in the offering (Meier et al., 2010). This is in line with theories of how dematerialization can reduce environmental impact (Mont, 2000). The life-cycle perspective was mentioned by the actors as a possible way of achieving a more durable railway when balancing the construction and maintenance costs. This is in line with previous research on infrastructure project (Pakkala, 2002; White et al., 1999). Suppliers involved in operational activities, e.g. maintenance, can establish feedback loops between the design phase and the railway operations (Geyer and Davies, 2000). Contractors believe that they can be more creative and thereby affect the rest of the life-cycle if they are involved in the design phase.

Similar to quality issues, to decrease the environmental impacts from the facilities environmental considerations need to be incorporated in the design phase to be efficient (Sakao, 2007). The actors focus is on cost reduction and process efficiency but this indirectly results in a focus on reduction of environmental impact as well. Contractors will, using the IPSO business model, make sure that the facility is as durable as possible to reduce maintenance and changing of spare parts, which implies less use of resources such as material and energy. The holistic IPSO view provides incentives for contractors to optimize the use of resources and realize more economical and environmental development (Lindahl et al., 2009; Tukker and Tischner, 2006).

6.3 Internal resistance and new competence

Only changing the business model and contracts would be insufficient, since the relational issues are required and determined by the business needs (Thompson et al., 1998). A major hurdle in this case seems to be the organization and culture at STA, which lacks a long-term overall perspective in combination with an internal reluctance to change and develop the process of contracting. The challenge is related to the change of mindset within the organization and the need for internal marketing (Sundin et al., 2009).

Providers need to develop new skills for understanding long-term risk as well as being able to identify, evaluate and manage risk (Brady et al., 2005). In this case, this goes for both contractors and STA due to the complex structure and the relations between the actors. A multi-skilled and cross-functional team is needed to produce the offering (Brady et al., 2005). Contractors can already identify potential synergies within their own organizations as a result the holistic work practice and the cross-functional approach. The construction and maintenance phases would benefit from the fact that the all knowledge would be in the same organization and solutions could be discussed from a life-cycle perspective. Previous research has shown that project with an integrated process such as IPSO projects for infrastructure results in that projects are completed faster (Pakkala, 2002). Other changes needed are more cooperation between the Investment and Traffic Divisions at STA and the need for both a general contractor and a technical contractor to fulfill the cross-functional skills needed.

6.4 Trust & improved information sharing

Risk of unpredictable costs can be reduced by access to resources, and the trust in a relationship can be helped by sharing information (Ng and Nudurupati, 2009). This shows how important transparency and information sharing will be for the IPSO contracts to work. IPSO contracts would provide incentives for documentation since the contractor has to demonstrate the value of the facility in the end of the contract as well as to have measures for evaluation during the contracts. For a contractor, upgrading or redesigning is not easy due to the technological lock-in. On the other hand, the processes for maintenance can be developed during the contract using the knowledge and experience gained during the use phase of the IPSO contracts , cf. Meier et al. (2010).

There is the possibility of supply chain disruption, and this fact has to be accepted and accounted for from the supplier’s side (Erkoyuncu et al., 2009). It has also been stated that a formal relationship is not enough for an IPSO contract, and for the partnership to be successful there is a need to align the profit incentives between them (Lockett et al., 2011). STA and contractors see themselves as parties with opposing interests. This could also mean that they have competing goals, which is opposite to what is recommended for mutual gains (Emden et al., 2006). There seems to be a lack of trust between the parties, which can lead to additional relational costs, cf. Bunduchi and Smart (2010). Long-term cooperation calls for common interests, shared risks and flexibility rather than making one side take all the risk (Nystén-Haarala et al., 2010). If contractors are going to use their knowledge to improve the infrastructure it is likely that some of their competitive advantage depend on keeping this knowledge within the firm. Therefore there needs to be regulations in the contract about how to deal with this so that the knowledge can transfer to other project within jeopardizing the innovation firm. There could e.g. be a delay for the use of the knowledge for anyone but the innovation firm.

7 Conclusions and future research

The lack of information transfer and knowledge integration is a barrier for innovation and the buyer’s conservative business culture makes it difficult to implement new types of contracts. IPSO requires improved information transfer, something which stimulates innovation as well as processes for evaluation of the contracts.

IPSO contracts provides a holistic life-cycle perspective and incentives for dematerialization, resulting in a more resource-efficient and durable infrastructure. By involving the contractors already in the design phase their knowledge could be used in a better way creating a feedback loop from practice to design.

Several challenges with IPSO are discussed, and most of them are derived from the risk and uncertainty aspects that come with long-term contracts and inexperience with a new business model. New competences in risk management and other types of calculation methods are needed but most of all a change in mindset. Some of these uncertainties also are connected to the inadequate documentation hindering IPSO contract working for anything but new investments.

7.1 Future research

The next step in this research will be to show this improvement potential in a quantitative way using life-cycle assessment and life-cycle cost analysis for environmental and economic calculations. This will be realized using scenarios relating to both current and IPSO contracts.

Additionally, the risk factors will be investigated more thoroughly as well as the functional requirements needed for an IPSO contract.

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