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EARLY SUPPLIER INVOLVEMENT (ESI) IN DUTCH INFRASTRUCTURE PROJECTS

An exploratory study to identify the current status of the Dutch infrastructure sector in terms of early supplier involvement

Early supplier involvement (ESI) in Dutch infrastructure projects

An exploratory study to identify the current status of the Dutch infrastructure sector in terms of early supplier involvement

By

S. Lotchouang Kouam

in partial fulfilment of the requirements for the degree of

Master of Science

in Construction Management and Engineering

at the Delft University of Technology,

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Colophon

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Preface

This thesis is submitted as an effort to partially fulfil the requirements for the degree of Master of Science in Construction Management and Engineering at Delft University of Technology in The Netherlands. The report entails an exploratory study regarding the current state-of-affairs of the Dutch infrastructure sector in terms of early supplier involvement (ESI).

My journey began in June 2017 when I was given the opportunity to research for my thesis within the company Fluor. Back then, I was curious about the London Heathrow Terminal 5 project and also concept such as early contractor involvement (ECI) and early supplier involvement (ESI). I remember the difficulty I had in the early phases of my research into finding the right topic. Initially, my interest was to study the London Heathrow Terminal 5 project and implement the lessons learned to the Dutch construction industry. However, after evaluating the possibilities and resources available for such research with my company supervisor Wouter van Der Bijl, that idea was abandoned. This was the first of many series of refinements in the prospect of finding a suitable research topic. Eventually consecutive discussions with Wouter, have helped me to really narrow down my focus, and together with Leon Hombergen, my university supervisor, we finally came to an agreement to research early supplier involvement and limit the research to the Dutch infrastructure sector. With the decision already made on the research topic, the next task was to complete the thesis committee and write a proposal. In this regard, I reached out to Professor Marcel Hertogh who accepted to chair my graduation committee and PhD candidate Wouter Kersten who accepted the role of second supervisor despite his busy schedule. Then I started working on my research proposal, which was officially kicked off in August 2017.

Throughout the past 6 months, I have been working on this research topic. Although the process itself was not an easy one, the experience was well enriching for me as a student and as a future professional. Digging into the topic of ESI and talking to different professionals in the Dutch infrastructure sector, has increased my understanding of the working culture in Dutch infrastructure projects and difficulties that parties often encounter.

All these wouldn't have been possible without some key people to whom I want to express my sincere gratitude.

I first want to thank Wouter van der Bijl, for being available whenever possible to give advice and review my work. I also particularly enjoyed those long and intense discussions we often had at the office where we would have opposite views and argue until time catches us off-guard. I will sincerely miss this part of my journey.

Professor Marcel Hertogh, thank you for accepting to chair this committee and for your very valuable and sharp critics and advice on my work.

Leon Hombergen I wish to thank you in particular for your supervision, but also for being there at the very beginning to help me clear the path and uncertainties I had regarding the topic to research. Sir you have always brought the right word to make me feel positive about what I was doing, and for that I will always be grateful to you.

Thank you Wouter Kersten, for all your valuable feedbacks regarding the process and form of my report. Also, I particularly appreciated your quick responses to my emails, which made communication very easy between us.

Similarly, I want to address my sincere gratitude to all the interviewees for their time and contribution to my research, particularly to Will de Groot for the special care he gave me during my visit to his company.

In a more personal note, I wish to thank my parents-in-law Sander and Hennie De Koning for all their moral support throughout this process, my girlfriend Laura De Koning for being able to manage me during that stressful period and my son Lisandro Lotchouang for always helping me remember that there was life next to a thesis. Finally, I wish to thank my dear parents in Cameroon for all their love and moral support despite the thousands miles separating us.

Samuel Lotchouang

December 2018

Summary

Background

Early supplier involvement (ESI) can be defined as the mechanism for involving key suppliers at early phases of a project. In the context of Dutch infrastructure projects, we define ESI as a form of buyer-supplier collaboration that takes place prior to the construction, maintenance and operation phase of a project. The concept itself is widely discussed in the context of New Product Development (NPD) and has been in existence for over half a century with positive results in a number of industries. The main idea is that buyers (client/contractor) do not know everything, and as such, should integrate suppliers with key competencies early in the process in order to 'better' execute a project. The level of supplier responsibility in ESI may range from simple consultation with suppliers on design ideas up to making suppliers fully responsible for the design of components or systems they will supply. Moreover, ESI often implies the establishment of cross-functional project teams composed of buyer and suppliers members.

In the Dutch infrastructure sector however, the implementation of the ESI concept is not yet as widespread as in the automotive or electronics industries. Furthermore, recent developments in the Dutch infrastructure sector have led to the introduction of more awarding criteria such as innovation, sustainability and speed. Consequently, reliance on suppliers' knowledge has become more important in projects.

ESI as a concept with positive results in other industries seems to be a potential solution for coping with those changes. It is believed that through ESI, it might be possible to bring suppliers input early on in the process thus facilitating early detection of risks and issues. Additionally, ESI might also imply a lesser dependency on contractors' knowledge and a lesser liability for contractors. In this regard, the opportunity to conduct this study emerges from the need to explore whether or not the Dutch infrastructure sector makes good use of suppliers' knowledge during early involvement, as not doing so could represent a missed opportunity for the sector.

Therefore, the objectives of this research are threefold:

- Investigate the current state of Dutch infrastructure projects in terms of early supplier involvement
- Identify barriers and stimuli to early supplier involvement in Dutch infrastructure projects
- Derive some recommendations for successful implementation of ESI in the building industry, based on literatures, lessons learned from other industries, interviews and questionnaires from experts.

Following the research objectives, the main research question is formulated as follow:

"What is the current status of Dutch infrastructure projects in terms of early supplier involvement: what barriers should be overcome and what areas should be stimulated in order to achieve success in early supplier involvement?"

Research methodology

Answering this main research question implied deriving a suitable strategy for gathering suitable data in regard of the topic at hand. Therefore, given the exploratory nature of this study combined to the difficulty to find suitable cases to study, a qualitative approach was chosen to conduct this research. Theoretical knowledge was gathered through literature study on key aspects such as the concept of ESI in New Product Development, supply chain integration and early private involvement in Dutch infrastructure. Based on some elements collected from the literature study, the interview questions were drafted. Next, empirical data were collected through semi-structured interviews with practitioners in the Dutch infrastructure sectors. In total 13 interviews regrouping 14 respondents were conducted, with 3 of those interviews used as background information. From the 14 respondents, 6 worked for the client organization, 4 for the contractor's and 4 for the supplier's. Next, interviews were transcribed verbatim and analysed with the qualitative analysis software MAXQDA following the grounded theory approach (open coding, axial coding and selective coding).

Findings

The interviews results have revealed that the practice of early supplier involvement is well present in Dutch infrastructure projects, although practitioners do not recognise it under the label 'ESI'. Moreover, data collected from the interviews have shown no signs of ESI taking place as part of client's requirements. Instead, the results suggest that by addressing certain issues during pre-tender discussions, clients have been able to indirectly raise awareness on the necessity to involve suppliers early in project. In addition, due to the last economic crisis that caused most Dutch contractors' organisation to reduce in size, it has become difficult for a single contractor to possess all capabilities for conducting a project on his own. Accordingly, involving suppliers earlier has become a strategic decision made by buyers who are becoming more aware of the need of external expertise in projects. An illustration of this increasing reliance on suppliers' knowledge can be seen in the standardisation of project aspects such as tunnel phone installations and road traffic signs, for which KPN and NBD (Nederlandse Bewegwijzeringsdienst) are respectively the preferred suppliers.

In terms of ESI practice, the results suggest suppliers' involvement in Dutch infrastructure projects as early as at the idea generation phase, during market consultation, competitive dialogue, proposal phase, or during the design and engineering phase.
Regarding the extent of involvement, four categories (''no involvement'', ''white box'', ''grey box'' and ''black box'') based on the model of Handfield et al. (1999) were used to illustrate the level of responsibilities given to suppliers in projects. From the model, all four categories have been reported as currently being implemented in Dutch infrastructure projects, with ''grey'' and ''black box'' categories related to suppliers of ICT components (tunnel phone installations).

In terms of buyer-supplier collaboration, the study has indicated some reluctance from parties to share key knowledge and information during early involvement. This has been attributed to factors such as the type of agreements (informal vs formal), the fear of losing proprietary knowledge, the necessity to maintain an edge on competitors and the lack of continuity (partners today competitors tomorrow). In this regard, the use of both non-legally enforced (''gentleman agreement'') and legally enforced agreements (NDA, EFA, RAAM) usually condition the collaboration between parties. However, due to initial uncertainties often surrounding Dutch infrastructure projects, it appears

difficult for parties to find a formula for sharing risks and rewards. Consequently, risks transfer to suppliers mostly depends on the nature of the contract between client and contractor. Moreover, it has been found that the use of Non-Disclosure Agreement (NDA) did not provide sufficient guarantees to encourage parties to share knowledge and information. Therefore solutions among which open-book accounting, ''gentleman agreement'' between top executives, reference visit are reportedly used to ensure trust and long-term commitment between parties.

None	''White Box''	''Grey Box''	''Black Box''
No supplier involvement. Supplier ''makes to print.''	Informal supplier integration. Buyer ''consults'' with supplier on buyer's design.	Formalized supplier integration. Joint development activity between buyer and supplier.	Design is primarily supplier driven, based on buyer's performance specifications

Spectrum of supplier involvement (Handfield et al., 1999)

From the study, several barriers to ESI in the Dutch infrastructure sector have been identified and attributed to:

- Opportunistic behaviour
- Cultural differences
- Absence of trust
- Restricted solution space
- Abstract level of information provided at pre-tender phases
- Conservative nature of the Dutch infrastructure sector
- One-off nature of infrastructure projects

Likewise, possible ways to overcome those barriers and stimulate ESI within the Dutch infrastructure sector are preconized as follow:

- Promote understanding of long-term aspect of ESI and avoid striving for short-term profits (hit and run mentality)
- Only provide relevant information and increase solution space

- Discuss topics that indirectly raise awareness on the need of ESI
- Invest more in finding risks and reward sharing formula
- Buyers should recognise the importance of their supplier and avoid squeezing the important ones
- More initiatives from suppliers in terms of trust and long-term commitment
- Establish criteria that obliges parties to work together after the project is won
- Top management should dedicate more effort in committing their staffs
- Standardise building blocks related to fast moving technology
- Have clear communication about risks and goals
- More control from the client

Overall, regarding the lessons that could be learned from other industries, this research has highlighted some key prerequisites that are necessary for a good ESI process. Among those, the study advocates trust, long-term commitment, formalised risks and reward sharing, knowledge and information exchange as the most important aspects that organisation considering ESI should focus on.

Limitation and suggestion for further research

The study performed in this graduation work only focused on a very restricted sample of participants. As such, the findings do not claim to be representative of ESI practices in the whole Dutch infrastructure sector. Another limitation of this research could also be the decision to opt for an interview-based study, as generally, data obtained from interviews do not represents hard facts, but instead are representative of interviewees' opinion. In the present case, the choice was made to check the consistency of the research findings with the literature.

It is suggested to have more specific studies regarding ESI aspects such as timing and extent of involvement. For instance, timing of involvement has been identified as major difficulty in ESI. Therefore, it could be ideal to look deeper into those aspects and perhaps come up with some kind of conceptual model or framework that could guide Dutch practitioners when engaged in an ESI process.
Another idea could be to develop a measurement tool that could serve to really evaluate how good the Dutch infrastructure sector is doing in terms of early supplier involvement. The idea here would be to conduct such research on a far bigger sample than the one represented in this study.
Furthermore, it could be interesting to investigate the practice of ESI per project type based on forms of collaboration such as Design and Construct (D&C), Design Build Finance and Maintain (DBFM) and many other types.

Recommendation
In general for all practitioners in the Dutch infrastructure sector, it is preconized for top management to double their efforts in ensuring stronger commitments from their staff.

On a more specific note, client should focus on providing the right information during initial discussions with project participants, as doing so will enable both contractors and suppliers to really know what to expect, and therefore have a better appreciation of risks and rewards.
Additionally, it is suggested that contractor should nurture their relationship with their key suppliers, for instance by providing sufficient incentives to keep those suppliers committed during early involvement.
Suppliers on the other hand should be able to recognise their most relevant customers and make extra efforts to show their trustworthiness and commitment to those customers, for instance through open-book accounting.

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Glossary of abbreviations and terms

CAPEX	Capital Expenditure
ECI	Early Contractor Involvement
EMAT	Economically Most Advantageous Tender
EPC	Engineer Procure Construct
ESI	Early Supplier Involvement
D&C	Design and Construct
DBFM	Design Build Finance Maintain
ICT	Information and Communication Technology
IP	Intellectual Property
IT	Information Technology
KPI	Key Performance Indicator
KPN	Posterijen, Telegrafie en Telefonie Nederland
MIRT	Meerjarenprogramma Infrastructuur, Ruimte en Transport
NBD	Nederlandse Bewegwijzeringsdienst
NPD	New Product Development
OPEX	Operational Expenditure
RAAM contract	A written agreement between supplier and buyer whereby the former undertakes to deliver goods at predetermined price and conditions in a certain period. The supplier is mainly given an indication of the quantity to be taken. The specific numbers and delivery times are determined in so-called call-off orders, also called raamorders
SCI	Supply Chain Integration

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Part I: Introduction

1 Introduction

1.1 Background

Early Supplier Involvement (ESI) is defined as a form of vertical cooperation where buyers involve suppliers at an early stage in the product development innovation process, generally at a conceptual and design level (Bidault et al., 1998). Since the beginning of the 1990's, several researches and literatures have drawn attention to the positive outcomes resulting from the adoption of ESI in a number of industries. In fact, the concept of ESI was first highlighted by Clark and Fujimoto (1991), to explain that the performance gap between westerners and Japanese cars manufacturers in virtually every domain was due to the adoption of the ESI process by the latter. In addition, some subsequent researches have demonstrated the significant benefits that Western cars manufacturers obtained by adopting the ESI practices of their Japanese competitor (Midler, 1994). It seems that these positive aspects could somehow justify the interest given to the ESI topic. However, one could also rightly wonder whether ESI practices could be permanently adopted in the building industry, particularly in Dutch infrastructure projects, and if so, which added value could it bring?

The building industry in contrast with other industries is characterised by its one-of-a-kind nature of projects, site production and temporary organization (Koskela, 2003). For decades, infrastructure projects have been refined through practices adopted from other industries, in order to improve efficiency and effectiveness. In the Netherlands, recent developments have resulted into the introduction of early involvement of private parties (early contractor involvement) in infrastructure projects (Lenferink et al., 2012). Among those developments, the introduction of the Public Procurement Act 2012 brought a remarkable change to the sector. A notable consequence of this new legislation was the introduction of a new award criterion for public procurement, namely the Economically Most Advantageous Tender (EMAT). According to EMAT, contracting authorities would now be able to consider criteria other than price for the tender procedure. This made possible for the client to integrate criteria such as innovation and sustainability as requirement for the tender. As a result, client's demands shifted from price into innovation, sustainability, creativity and better optimization of the supply chain.

Those new client's requirements probably explain why some approaches similar to ESI have often been observed in Dutch infrastructure projects. This was for instance the case for the Rotterdamsebaan project (Den Haag, 2017), where suppliers assisted contractors in developing their sustainable solution during the tender.

It is believed that through ESI, client, contractors and suppliers could be brought to collaborate more closely, in order to avoid ending up in undesired outcomes. The possibility for suppliers to bring their inputs early on in the process might be beneficial for early detection of risks and problems, or even for improving the quality of the asset or service to be delivered. Moreover, ESI might represent an opportunity for the client to exert some kind of control over project processes,

and a lesser dependence on contractors. Eventually, ESI adoption in Dutch infrastructure projects might also imply a lesser liability for contractors. It is thus relevant to explore the level of early involvement of suppliers already achieved so far in Dutch infrastructure projects, and to question the real added value of involving those suppliers early on in projects. In other words, are suppliers really influencing the solution, thus bringing a positive input when involved earlier or are they just involved to give an illusion of fulfilling client's requirement? An investigation of the current status of supplier involvement in Dutch infrastructure projects, particularly in terms of timing and level of responsibility given to suppliers, might bring some elements of answers to those questions.

1.2 Scope and delineation of the research

This study is an exploratory research on the implementation of the concept of early supplier involvement in Dutch infrastructure projects. The focus is aimed at investigating the current status of the Dutch infrastructure sector in terms of early supplier involvement, identifying potential barriers and stimuli, and deriving some key recommendations for the sector. Consequently for this research, the boundary is restricted to the Dutch infrastructure sector.

In this study, we define a supplier as an entity or organisation that can deliver product, services or both. As such, subcontractors, suppliers of materials, equipment or services can be considered as suppliers. In that sense, main contractors are not considered as suppliers. Therefore in this report, any reference made to the term 'buyer-supplier' within the Dutch infrastructure sector should be understood as either 'client-supplier' or 'contractor-supplier'. In that sense, the word 'buyer' should be interpreted as either 'client' or 'contractor'. Additionally, in chapter 3 of this report, manufacturers are sometimes referred to as ''buyer'', which can lead to confusion. Therefore for demarcation in this research, as far as the Dutch infrastructure sector is concerned, a manufacturer will be considered as a supplier.

Moreover, the understanding of the term ''extent of suppliers' involvement'' might lead to different interpretation. Therefore for clarification, in this research the term ''extent of suppliers' involvement'' as mentioned in sub-question 3, refers to the different level of responsibilities that suppliers are given in projects. In other words, it implies listing the different categories of responsibilities given to suppliers without quantifying those. Consequently, the extent of suppliers' involvement in terms of proportion will not be part of this research.

1.3 Structure of the report

This report is an exploratory research on the practice of early supplier involvement (ESI) within the Dutch infrastructure sector.

The report is divided in four parts with a total of 10 chapters.

In part I, background information about the research topic and the scope of the research are given, followed by the formulation of the problem, research objectives and questions and the method of research.

In part II, a review of relevant literatures is presented. In this regard, literature study is performed on the concept of ESI in new product development, followed by theories on supply chain integration and early private involvement in the Dutch construction industry.

Part III consists in analysing the collected data and reporting the findings from the different interviews. In the next chapter, the research findings are further discussed, and some limitations of this study are given followed by recommendation for subsequent studies.

Finally, the research is brought to a close through the conclusion chapter where the main research question and the sub research questions are answered, followed by some recommendations to practitioners in the Dutch infrastructure sector.

2 Research design

In this chapter the research problem is defined, followed by the formulation of the research objectives, research and sub research question. The chapter ends with a method section where the chosen approach to conduct this research is explained.

2.1 Problem statement

Recent developments in the Dutch construction industry have shifted responsibilities of clients and contractors and have contributed to an increased use of integrated contracts. Throughout years, client demands have changed focus from price onto criteria such as innovation, sustainability and speed (Bemelmans et al., 2012). Consequently, reliance on supplier's knowledge has become more important in project. Nowadays, the contracting authority expects from contractors to better optimise their supply chain and make better use of suppliers' knowledge.

Early supplier involvement as a concept that has been applied in other industries for quite a while now with positive results has been advocated as a potential solution to better cope with those changes (R. McIvor & P. Humphreys, 2003). However in the Netherlands, the implementation of ESI in infrastructure projects is still not widespread in comparison to industries such as the automotive or electronics industry. This is probably due to the unique nature of infrastructure projects in comparison to projects from other industries. Moreover, for some rare infrastructure projects where suppliers have been involved in early stages, there is still a concern regarding the solution space given to those suppliers during early involvement. In other words, is the Dutch infrastructure sector really making good use of suppliers' knowledge during early involvement? Are suppliers being given the right level of responsibility they should have or are they just involved in order to give an illusion of fulfilling the client's requirements? In itself, this could represent a missed opportunity for the Dutch infrastructure sector, as ESI might be a good alternative in dealing with projects in a better way, and as such can be considered problematic as a whole

2.2 Research objectives

Currently in Dutch infrastructure projects, there is an increasing demand from the client side about more innovation, sustainability and better optimization of the supply chain. In order to cope with those demands, there has been an increase reliance on supplier's input in projects. However, the question that one can rightly have is to know whether that increasing supplier involvement is properly done or whether suppliers are just involved to give an illusion of fulfilling client's requirement. Perhaps investigating the current state of affairs of the Dutch infrastructure sector in terms of early supplier involvement might help to shed light to those interrogations. Therefore, the objective of this research is threefold:

- Investigate the current state of Dutch infrastructure projects in terms of early supplier involvement

- Identify barriers and stimuli to early supplier involvement in Dutch infrastructure projects
- Derive some recommendations for successful implementation of ESI in the building industry, based on literatures, lessons learned from other industries, interviews and questionnaires from experts.

2.3 Research questions

Given these objectives, the research question that will be investigated can be formulated as follow:

"What is the current status of Dutch infrastructure projects in terms of early supplier involvement: what barriers should be overcome and what areas should be stimulated in order to achieve success in early supplier involvement?"

In order to answer this research question, sub-research questions will be necessary and are formulated as follow:

SQ1: What is early supplier involvement and how is it applied in other industries?

SQ2: What lessons could be learned from other industries in terms of early supplier involvement?

SQ3: What is the extent of suppliers' involvement in Dutch infrastructure projects?

SQ4: What are the barriers and stimuli to successful early supplier involvement in Dutch infrastructure projects?

SQ5: Which key project-aspects can justify involving suppliers earlier?

2.4 Research methodology

Accurate data and appropriate strategies are important pre-requisites in conducting an effective research. This is particularly true when the research is directed towards a topic that is not widely discussed within a specific industry. In this section, the strategies and approaches used in this research are explained.

2.4.1 Literature review:

This phase consisted in acquiring sufficient theoretical knowledge on the different aspects of the research topic. In this regard, intensive literature study was performed on key aspects such as the concept of early supplier involvement (ESI) in new product development (NPD), supply chain integration and early private involvement in the Dutch infrastructure sector. In the following paragraphs, explanations are given on my motivations for choosing those topics for study.

2.4.1.1 The concept of early supplier involvement (ESI) in new product development (NPD):

An intensive literature study on the concept of early supplier involvement (ESI) was performed because this topic constitutes the central theme of my research. Studying the ESI concept was essential to understand the concept as a whole (*origins, definition, benefits, barriers and limitations).* For this purpose, my strategy in reviewing literatures on ESI was directed towards key aspects such as buyer-supplier relation, ESI implementation (especially questions related to the timing of ESI). Regarding the latter, I found there were many articles and books treating ESI implementation, particularly in relation with the electronics and automotive industry. However, it was proven difficult to find literatures providing a comprehensive guideline for implementing ESI. This was certainly due to the fact that ESI is a concept used/adapted by firms to meet their specific needs. It was then important to gather sufficient knowledge on how ESI is viewed and applied in other sectors, and what lessons could be learnt from those sectors. In this regard, the article of Humphreys et al. (2003) provided some good information regarding buyer-supplier relationship and the application of ESI. The article examined the degree of early supplier involvement that exists between multinational electronic companies and its suppliers in terms of depth of integration, information exchange and buyer-supplier relationship. The authors also presented the strategic factors affecting the ESI process. The article was particularly useful for giving me first impressions regarding the management of the ESI process and the barriers to effective integration of suppliers. At the end of the paper, the authors provided some useful recommendations for organization that would consider adopting ESI, based on the lesson learned from the findings of the research. Given the fact that there were not any documents or standards available explaining how to implement ESI in infrastructure projects, this paper was of valuable importance to my research, particularly because it highlighted point of interests that the construction industry should be aware of, if ever considering future implementation of ESI. From that point forward, it was possible to explore the topic in some more depth.

2.4.1.2 *Supply chain integration:*

Reasons for studying this topic lays in the fact that the ESI concept seemed to be linked to supply chain integration. In other words, involving suppliers earlier somehow requires achieving a certain degree of integration and vice versa. Regarding supply chain integration, there were many literatures treating this aspect available online. In this regard, the doctoral paper of Vrijhoef (2011) provided a good starting point into this topic, as it highlighted key aspects related to the implementation of supply chain integration in the building industry. Similarly, the paper of Briscoe et al. (2004) showed the influence that client's organization can have on supply chain integration. In the paper, the authors emphasised on the role of client as key decision-maker in choice of procurement types for project. The paper also establishes a relation between environmental factors, procurement decisions and the degree of supply chain integration. Having all these background data from these two initial documents, my strategy in studying this topic intentionally focused on reviewing the concept as a whole (definitions, approach, benefits and barriers), and particularly success factors and the influence of client's procurement decision on supply chain integration. Regarding the latter, one could believe it to be necessary because the client, as the initiator of infrastructure projects, can influence the integration process. Thus, perhaps understanding these key aspects, could help identify the potential role client could take in order to facilitate the early supplier involvement process.

2.4.1.3 *Early private involvement in the Dutch infrastructure sector:*

The necessity of studying this aspect of the research came from the importance of positioning the ESI concept within the Dutch infrastructure world. As such, early private involvement was a good candidate for studying. It was thus essential to have a closer look on this new way of working that has been introduced in the Dutch infrastructure industry during the last decade. Although this topic was not covered in depth in the report, it was very important in understanding what the infrastructure sector had already achieved in terms of early supplier involvement.

2.4.2 Expert interviews:

Regarding the formulation of the research objectives and questions, it seemed logic to collect empirical data through single or multiple case studies. However, following some discussions with my supervisors, the choice was made to use interviews as the main approach to gather empirical knowledge. Here, the decision not to follow a case study approach was made for 2 reasons: on one hand my initial aim was to study cases featuring completed projects where there have been intensive involvements of suppliers and where the company Fluor was involved. However, given the uncertainty I initially had regarding the implementation of ESI within the Dutch infrastructure sector, combined to the difficulty to find literature regarding ESI implementation in Dutch infrastructure projects, it appeared difficult to find infrastructure projects fulfilling those conditions.

On the other hand, when I found projects fulfilling those conditions for study, there was still an issue due to the fact that those projects were still ongoing, which in my opinion, would have made it difficult for case study due to confidentiality around certain data. Therefore, the choice was made to gather empirical knowledge through an interview approach.

Additional reasons for choosing interview with experts as data gathering method were because, firstly, it gave me the possibility to collect non-predetermined answers. Secondly, it allowed me to best assemble the insights and interpretations of respondents, which in turn improved my understanding of the context. Thirdly, because the interviews were held over time, it gave me the flexibility to adapt some of my questions regarding certain respondents.

However, as far as I recognised the importance of conducting the interview with experts, I also acknowledged some challenges in doing so. For instance, the fact that the interviews were conducted face-to-face somehow reduced the anonymity I had promised to my interviewee. A direct consequence of this could have been a reluctance of my interviewees to share certain information. Therefore, being aware of that potential issue, I took in advance some measures such as promising my interviewees to send them the interview transcript later on for check, and reassuring them multiple times during the interview that their information will be treated anonymously.

Another disadvantage of conducting expert interview is related to time schedule. In fact, all interviews I did were restricted in time and scheduled during working hours. Here the risk was that interviewee would fill time pressure, and therefore rush in their answers, or perhaps ask additional questions that would squeeze out the allocated time for the interview. Thus, in order to mitigate those potential negative effects, I always introduced a brief overview of the context and topic of the interview during my ''request for interview'' email to the respondents. Moreover, it was also made explicit to interviewees, the possibility to respond to unanswered questions later on by email. I believe these measures allowed interviewee to take their time and give valuable answers to my questions.

Finally, the most challenging difficulty with conducting the interviews was to make sure that the respondents maintain focus on the topic, without losing the natural flow of the conversation. In order to address that challenge, I opted for a semi-structured interview approach, which allowed me to adapt the sequence of my questions to the respondents' answers.

	Theoretical foundations			Empirical research
	ESI concept	Supply chain integration	Early private involvement in the Dutch infrastructure sector	▪ Interviews with public parties ▪ Interviews with market parties
Methodology	Literature review			Semi-structured interviews
Expectations in terms of answers to research questions	Answer SQ1 Answer SQ2			Answer SQ3 Answer SQ4 Answer SQ5

Table 2. 1: Research strategy

Part II: Theoretical background

3 Early supplier involvement (ESI) in new product development (NPD)

This chapter presents the concept of early supplier involvement (ESI) as retrieved from different literatures. The aim here is to answer the first and second sub research question: *"what is early supplier involvement and how is it applied in other industries?"* and *"what lessons could be learned from other industries in terms of early supplier involvement?"*. In this regard, ESI aspects such as timing and extent of involvement are discussed within this chapter. In addition, an overview of the different benefits, limitations, barriers and success factors to ESI will also be presented.

3.1 Definition

Dowlatshahi (1997) defines early supplier involvement as a mechanism for involving preferred suppliers in the early phases of product design and development. Other scholars have defined ESI as a means of integrating suppliers' capabilities in the buying firm's supply chain system and operation (Dobler and Burt, 1996). Cousins (2005) on the other hand, simply defines ESI as a strategic type of vertical buyer-supplier collaboration.

In academic literatures, researchers widely discuss the ESI concept in the context of New Product Development (NPD). By definition, early supplier involvement can be recognized from other types of collaboration due to the fact that it occurs prior to regular production or operation. As a result, a number of scholars utilize the terminologies 'supplier involvement' and 'early supplier involvement' interchangeably in order to describe collaboration prior to regular operations. Some researchers on the other hand, differentiate these terminologies with regards to the timing of suppliers' involvement during the development stage (Mikkola and Skjøtt-Larsen, 2006; Petersen et al., 2005). In this regard, Ragatz et al. (1997) argues that supplier involvement represents the collaboration in one phase of the project, whereas early supplier involvement covers the assessment, concept and design/engineering phase. Similarly, some scholars use the term early supplier integration to refer to early supplier involvement. However, this might lead to confusion and therefore, the remainder of this report will stick as much as possible to the terminology 'early supplier involvement' (ESI).

Basically, there is a whole variety of different types of supplier involvement as outlined by literatures, yet ESI tends to be differentiated from various forms of supplier involvement since it typically takes place prior to the regular production (Clark, 1989; Kamath and Liker, 1994; Bidault et al., 1995). From this type of reasoning, Bidault et al. (1998b) believe that ESI pertains to a form of vertical cooperation in which manufacturers involve suppliers at an early stage during the product development innovation process, usually at the level of concept and design.

3.2 Origins

Although the practice of early supplier involvement in New Product Development (NPD) has been in existence for more than fifty years (Wynstra et al. 2001), it is only in the 1980's that this topic has gotten proper consideration in academic literatures (Parker et al., 2008). This period is often referred to as the period of the "Japanese miracle". Consequently, a great deal of researches strived to comprehend and explain the reason and strategies behind the success of Japanese companies in terms of competitiveness and efficiency (Amaral et al., 2002).

The first ever recorded research pointing toward the importance of supplier involvement in NPD originates from the studies of Imai, Takeuchi and Nonaka (1985). In that early contribution, the authors linked the superior performance of Japanese companies to their extensive involvement of suppliers in NPD projects. It was until the end of the 1980's and the beginning of the 1990's that Clark (1989) highlighted for the first time the concept of ESI in NPD. In 1991, Clark and Fujimoto further described the importance of supplier involvement by comparing the performance gaps between Japanese and western car manufacturing companies.

3.3 Timing of involvement: How early should suppliers be involved?

The timing of supplier involvement refers to the phase from which the client actually starts to look for adequate suppliers and make them mindful of the project (McIvor et al., 2006). According to Petersen et al. (2005), the timing of supplier involvement provides a moderating impact on enhanced design in addition to financial performance. In figure 3.1, Handfield et al. (1999) showcase five different stages of the new product development process at which supplier could be involved.

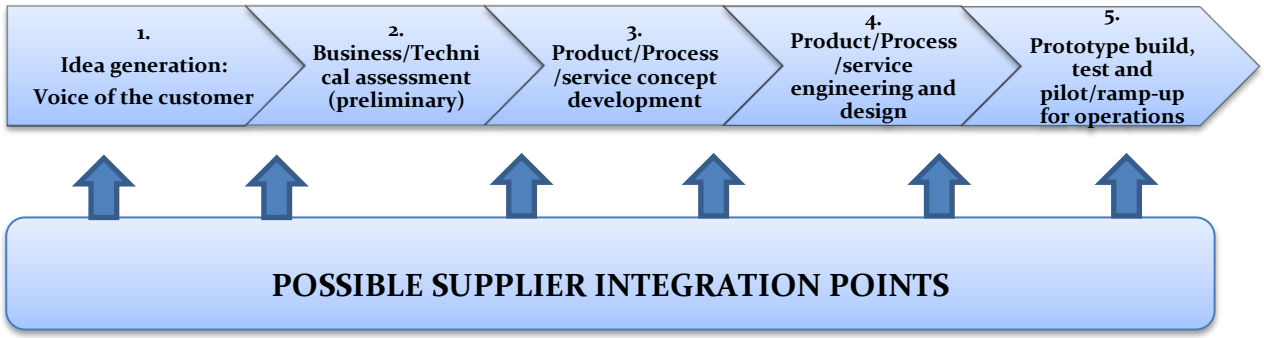

Figure 3. 1: possible supplier involvement stages (Handfield et al., 1999)

According to Handfield et al. (1999), in stage 1 designer and marketing staff evaluate the demand for the product and typically engage clients for their solutions and input regarding the added value and cost of such a product/process/service. Also, in case an existing supplier possesses an exciting new technology, this stage gives the opportunity to assess the potential of such technology. Stage 2 is where the team executes a business evaluation of the product and identifies which technical solution will be appropriate for the client's requirements. Stage 3 consists in formulating an in depth idea for

the project and the supply chain collaboration, then selecting the appropriate technologies. Stage 4 marks the start of the actual development process. At this point both supplying and purchasing organization produce blueprint and design specifications. Finally in stage 5, the product goes into full-scale production and suppliers' volumes are ramped up.

From the description of each phase of figure 3.1, it makes sense to assume that suppliers could be involved at any stage of the process. However, the timing of supplier involvement continues to be one of the leading causes of discussion among industry experts and scholars. For instance, Petersen et al. (2005) claim that supplier involvement is possible in every phase of the project, whereas Mikkola and Skjøtt-Larsen (2006) are convinced that involvement during the first and second stage isn't likely due to the fact that organizations appear to consider the actions occurring during these stages as their key competencies. Based on this divergence in opinions, it seems that the ideal time to involving suppliers depends upon the buyer's preferred type of project setup.

In general, Scholars describe the timing associated with supplier involvement basing their study in various aspects that have an impact on the actual timing. For instance, Eisenhardt and Tabrizi (1995) claim that predictability or complexity can influence the timing of supplier involvement. In this regard, Wagner and Hoegl (2006) believe that the more a project is complex and requires knowledge input at the beginning of the project, the more required will be the involvement of suppliers at early stages of the project.

Moreover among other aspects, technology uncertainty can also be considered as very influential for the timing of suppliers' involvement. This claim is supported by Ragatz et al. (2002) who believe that suppliers possessing high technical capabilities should be involved as early as possible in projects where the buyer organization does not possess the level of expertise required for some technical components. However, additional findings in the role of technology uncertainty remain conflicting. For instance, Wasti and Liker (1997) claim that supplier involvement can be positively influenced when technology uncertainty is combined with suppliers' technical abilities. Swink (1999) in contrast, while studying manufacturability and the effects of development team integration process, discovered strong relations between supplier influence and improved manufacturability, on the other hand he also found that those strong relation diminished in situation of high product 'newness'. The findings of Swink (1999) somehow indicate the doubts that prevail regarding the benefits of supplier involvement in product displaying a high level of uncertainties.

There is evidence to demonstrate that earlier involvement is advantageous in the event of higher technology uncertainty; however, the rewards of doing so tend to be countered by the drawbacks of becoming "locked into" a specific supplier, particularly when there are multiple competing technologies competing to become the industry norm (Handfield et al., 1999). Regarding the question *"how early should supplier be involved"*, Handfield et al. (1999) advocates that two factors should be taken into account, namely the rate of technology change and the degree of supplier expertise in the given technology. In other words, timing should be done with respect to the technology and categories of suppliers involved. This idea is further illustrated by figure 3.2 where an overview of the timing of involvement and the types of suppliers is given.

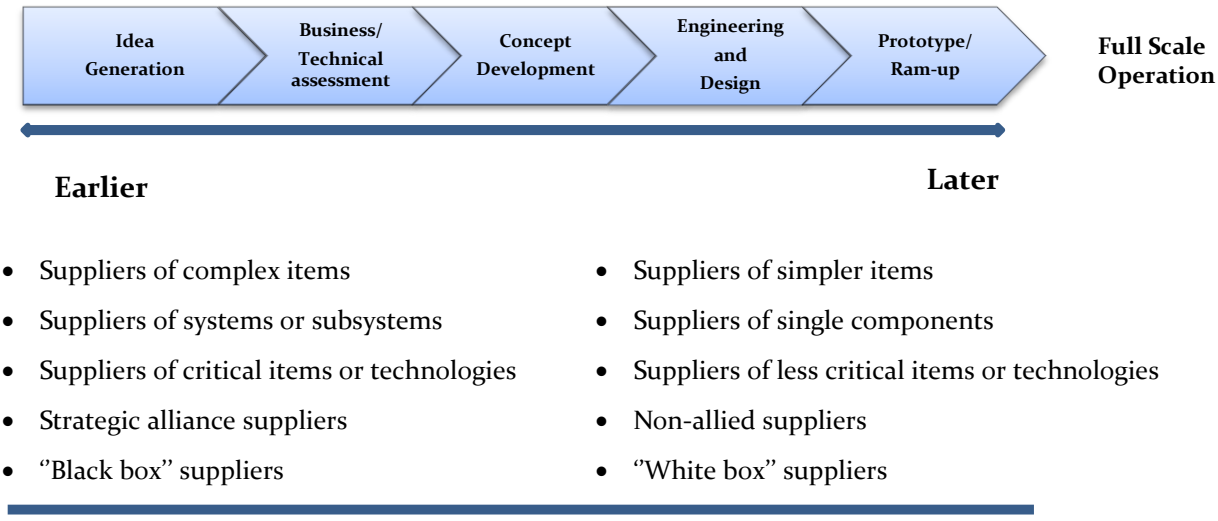

Figure 3. 2: Timing of involvement based on the categories of suppliers (Handfield et al., 1999)

Figure 3.2 shows that suppliers of complex items should be involved at the very beginning of the process. This is certainly due to the fact that complex items are often components that are critical for the product development process, and as such, the earlier the involvement, the more room the supplier will have in order to provide its key insight for crafting the new product.

In contrast, suppliers of less critical items should be involved at the later stage of the process. That can certainly be explained by the fact that usually, the development of less critical items is moved forward in the process. Moreover, as Bonaccorsi and Lipparini (1994) pointed out, there can be potential risks associated with involving suppliers of less critical items too early in the process.

Considering the fact that the timing of involvement is conditioned by the technology and the degree of supplier expertise, it seems that the nature of the project also has an influence on the timing. To the question *''how early should supplier be involved''*, there is obviously no clear answer, because the timing of supplier involvement depends on many parameters (McIvor et al., 2006). There is simply no exact moment in time throughout the development process in which the supplier must be involved. Instead as recommended by Ragatz et al. (2002), suppliers could be involved in different points of the development process, regarding the type of project, the type of suppliers, the degree of technological uncertainty, and the degree of innovation in the project. Consequently, it seems logic to assume that suppliers should be involved earlier in project with high degree of innovation than on projects which are less critical.

Now assuming that suppliers are involved earlier, one could rightfully wonder about the extent of supplier involvement. In other words, how much responsibility do suppliers bear in early involvement and how far can suppliers bring their input? In the next section, an attempt will be made to answer those questions.

3.4 Extent of supplier involvement: How much responsibility should be given to suppliers?

Numerous organizations progressively become aware that supplier involvement in new product development could be worthwhile with regard to the costs as well as the quality of new products and also the expenses and time related to their development. As a result, a growing number of suppliers are becoming involved in their clients' development projects (Wynstra et al., 2000). However, as pointed out by previous researches (Hartley, 1994; Wynstra, 1998), early supplier involvement does not always lead to success in terms of project efficiency (development cost and time) and effectiveness (product cost and quality). Yet, those findings do not intend to refute the importance of ESI, but rather emphasize that supplier involvement should be managed carefully.

Generally, the range of supplier involvement can go from inputting minor design suggestion up to holding full responsibilities for complete development, design and engineering of components or system to be supplied (Wynstra et al., 2000). However, this characterization does not represent the full extent of supplier involvement. In literatures, several representations of the degree of supplier involvement are given. In this section, the focus will be directed towards the model of supplier level of responsibility developed by Handfield et al. (1999) and Wynstra and Pierick (2000).

In 1999, Handfield et al. proposed a model of supplier level of responsibility, as shown in figure 3.3. In the model, the level of responsibility of suppliers ranges from ''no involvement'', to ''white box'', ''grey box'' and ''black box''. Accordingly, the authors classified those suppliers respectively as ''white box suppliers'', ''grey box suppliers'' and ''black box suppliers''.

None	''White Box''	''Grey Box''	''Black Box''
No supplier involvement. Supplier ''makes to print.''	Informal supplier integration. Buyer ''consults'' with supplier on buyer's design.	Formalized supplier integration. Joint development activity between buyer and supplier.	Design is primarily supplier driven, based on buyer's performance specifications

Increasing supplier responsibility

Figure 3. 3: spectrum of supplier involvement (Handfield et al., 1999)

This model seems useful to understand the degree of importance of suppliers and their role in the process. For instance, the ''none'' category of the model refers to contexts where suppliers do not bring any input to the process. This can for instance be the case for projects where suppliers are only required to follow the instructions and design from the buyer's organization, i.e. ''makes to print'' as shown in the model. In this context there is no need of supplier involvement. The ''white box''

category corresponds to situation where suppliers are invited to discuss about specifications/requirements. However, the design and specification decisions belong to the buying organization. In the ''grey box" category on the other hand, suppliers' responsibilities are somehow increased. Here the client together with the supplier get into an informal, or sometimes a formal combined development effort, which could consist of sharing information and technology and joint decision making with regards to design specification. Finally, within the ''black box" category, the supplier is notified regarding the client's requirements and is granted full responsibility for the purchased product. Here the buying company only reviews the specifications of the purchase products. In other words, the design is mainly supplier driven in line with the buyer's performance specifications. This last category (''black box") represents the highest level of supplier involvement (Petersen et al., 2005).

Wynstra and Pierick (2000) on the other hand looked into the key issue related to the involvement of many suppliers simultaneously. Based on an intensive case study of a Dutch medical equipment manufacturer, the authors developed a model named the ''supplier involvement portfolio" (as shown in figure 3.4). This portfolio makes the distinction between four categories of supplier involvement based on two variables, namely the degree of development responsibility held by the supplier and the development risk.

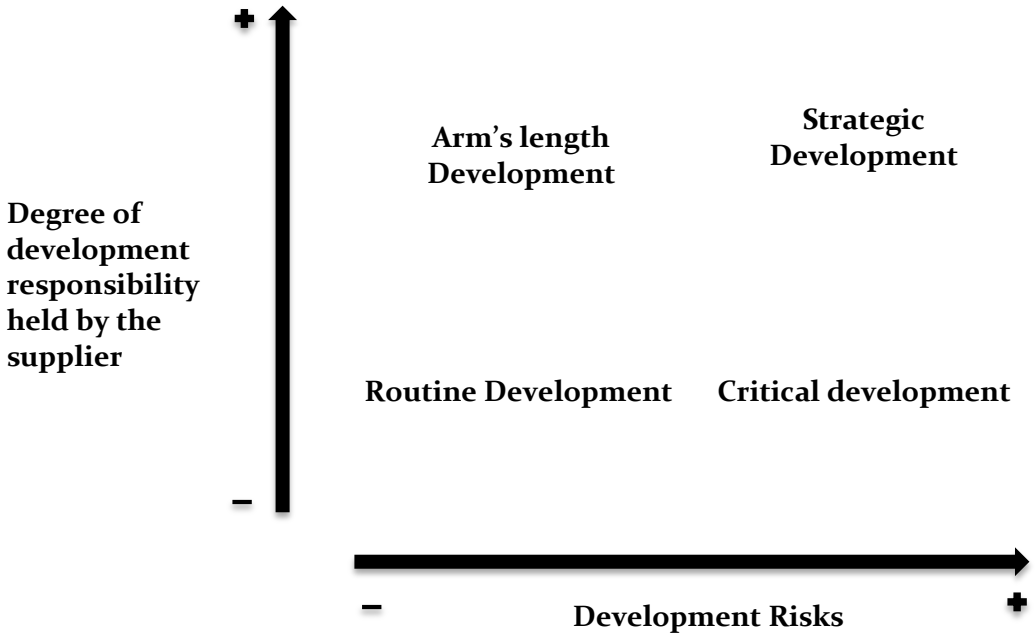

Figure 3. 4: Supplier involvement portfolio (Wynstra and Pierick, 2000)

In figure 3.4, the vertical axis refers to the degree of development responsibility agreed upon with the supplier. This degree of responsibility given to the supplier is also highly dependent on the difference in knowledge, know-how and experience between buyer and supplier, and also affects the phase of involvement. For instance, suppliers to which has been given major responsibility for the

development of a new component is more likely to be involved in early phases of the development project (Wynstra and Pierick, 2000). The horizontal axis on the other hand (development risk) refers to how important, innovative and complex the development process is. It gives an indication of the time and effort required for the development process.
Based on those two variables, Wynstra and Pierick (2000) derived four categories of supplier involvement namely: *strategic development, critical development, arm's-length development* and *routine development.*

- ***Strategic development***: characterised by high development responsibility for the supplier and high development risk. Here the supplier is responsible for the global design using functional specifications. According to Wynstra et al., suppliers belonging to this quadrant should be the first to be involved in the development project.

- ***Critical development***: characterised by low development responsibility and high development risk for the supplier. This low level of responsibility is often limited to connecting pieces or purchasing near-standard parts that are necessary for the progress of the development project. Hence, suppliers belonging to this category are contacted early on for information.

- ***Arm's-length development:*** in this case, the development risk is considerably lower as opposed to strategic development, however a major part of the development is given to the supplier. Also, in contrast with strategic development, here the development responsibility is awarded in a more formal way and the relationship is significantly less tight. Suppliers from this quadrant fulfil their development responsibility based on ''vague information'' (functional specification)

- ***Routine development:*** suppliers in this category have little to no development responsibility and also low development risk. Here, the manufacturer or buyer's organization overseas most of the responsibilities (technical specifications, changes coordination). Suppliers belonging to this category see their responsibility reduced to updating the buyer about any changes, costs and specification.

	Strategic Development	**Critical Development**	**Arm's-Length Development**	**Routine Development**
Kind of collaboration	Close co-operation as 'sparring partners': joint development	Focus on obtaining information	Independent development by supplier	Informing each other about changes

Table 3. 1: overview collaboration model (Wynstra and Pierick, 2000)

3.5 Benefits of ESI

Given the importance that the ESI topic has gained during the last two decades, it is logic to assume that ESI, when properly implemented, can yield to great results in new product development. Previous researches have shown that ESI can offer a multitude of benefits. In terms of benefits of supplier involvement, a distinction can be made between short and long-term benefits. In this section, some of those benefits are presented.

3.5.1 Short-term benefits

In the short-term, Wynstra et al. (2001) believe that supplier involvement can be beneficial in achieving both efficiency and effectiveness.

Efficiency

Regarding efficiency, the authors claim that supplier involvement is very useful in *reducing both development cost and development lead-time*. This can be explained by the fact that early and intensive communication with supplier can help preventing, reducing or introducing design changes earlier. Furthermore, ESI gives the opportunity to separate development tasks as well as develop multiple components and segments in parallel, hence eliminating capacity bottlenecks within the manufacturing's engineering department. Finally, efficiency is also stimulated when for each phase in a development project, design responsibility is given to the most capable of the two parties (supplier or buyer/manufacturer).

Effectiveness

In terms of effectiveness, supplier involvement can be beneficial in *reducing product cost* by using supplier's knowledge to find alternative material or possibly use supplier's skills to standardise component (Wynstra et al., 2001; Wasti and Liker, 1997). It can also be beneficial in *improving product quality* by putting supplier's expertise into contribution in assessing the quality and reliability of designed components (Wynstra et al., 2001; Wasti and Liker, 1997).

3.5.2 Long-term benefits

Utilisation of suppliers' technological expertise

In the long-term, it is believed that through supplier involvement, buyer/manufacturer can gain (long-term) access to the supplier's technological knowledge (Van Echtelt et al., 2008). Eventually the buyer/manufacturer might also be interested in influencing the choice of technology used by the supplier in order to achieve more effective technological collaboration in the future (Wynstra et al., 2001).

Managing outcome uncertainty

In situation of technological uncertainty, some scholars have found ESI to be particularly beneficial. Wasti and Liker (1997) discovered that involving top-tiers suppliers as early as in the conceptual and planning phase is very beneficial in case of high technological uncertainty, as such early involvement

facilitate the development of workable and better solution through combination of companies' expertise and abilities. Similarly, According to Ragatz et al. (2002), implementing ESI in case of technological uncertainty results in a significant reduction of development time from concept to launch, as well as an increase in quality and a reduction in cost.

Reduction of supply risk

Zsidisin and Smith (2005) on the other hand, discovered through their case study research that ESI can be very beneficial in reducing supply risk, provided that the right conditions are met in new product development. By reducing supply risk, the authors imply preventing possible failure in the product or activities executed by suppliers. This could be achieved by choosing suppliers based on appropriate selection criteria, setting tasks and objectives for those suppliers, keeping track of their performance, managing outcome uncertainties and having shared objectives between buyer and suppliers (Zsidisin and Smith, 2005). This importance of ESI in reducing risks is quite interesting, as it indicates that the benefits of ESI are not limited to design inputs, but can also help companies in reducing risks and uncertainty regarding suppliers and the end product.

ESI benefits	References
Reduction of development cost	Wynstra et al. (2001)
Reduction of development lead time	Wynstra et al. (2001)
Reduction in production cost	Wynstra et al., 2001; Wasti and Liker, 1997.
Reduction of time-to-market	Ragatz et al. (2002)
Better product quality	Wynstra et al., 2001; Wasti and Liker, 1997
Increased access to key technology	Van Echtelt et al., 2008; Wynstra et al., 2001
Management of outcome uncertainties	Wasti and Liker (1997)
Reduction of supply risks	Zsidisin and Smith (2005)

Table 3. 2: Some suggested ESI benefits

Despite the fact that those ESI benefits have been heavily relayed in literatures, there are nevertheless some few studies that still question those ESI advantages. For instance, some studies have found no evidence supporting the fact that involving suppliers early and giving them more responsibility in design had a positive impact in improving the quality of the end product and reducing both cost and time (Hartley et al., 1997a; McCutcheon et al., 1997). Similarly, in the study conducted by Birou (1994), it was demonstrated that involving suppliers can cause an increase product and development cost, and from time to time can also lead to poor product performance and even longer development time. In the same spirit, Primo and Amundson (2002) while studying the benefits associated with the use of ESI could also not trace back any positive impact in cost and time reduction. These contradictory findings are somehow not surprising, as organization and people's mind-set can change depending on the context and culture. In fact, ESI practice is not straightforward, and as such, organizations can steer it to achieve their own desired benefits. Thus it is perhaps logic, to assume that whether benefits can be achieved or not depends on the way the ESI process is managed. Hence, in the following section, the downsides of ESI will be reviewed.

3.6 Review of ESI limitations

In the previous section, it has been shown that ESI can yield various benefits for organization implementing it in the right way. However, similar to other concepts or practices, ESI also possesses some weaknesses that need to be considered while implementing it.

Among the many disadvantages of ESI, Sobrero and Roberts (2002) stress that ESI can be a *resource and time absorbing solution*. If not executed the right way, ESI could without a doubt evolve into a process that will no longer be ideal for the purchasing firm. Moreover, in cases ESI is not implemented in the proper instance, it could lead to squandering of supplies for the firm.

Another drawback of ESI can be related to knowledge. Indeed, one of the main reasons for involving suppliers early is because of their in-house technical capabilities (Wasti and Liker, 1997). However, this can also be the cause for troubles. Mikkola and Skjoett-Larsen (2003) resume the main weaknesses together with issues connected with ESI to be the possibility of losing proprietary knowledge, the loss of internal key-competencies, the likelihood for competitors to have access to or even reproduce key technologies by means of employing the same supplier, as well as the increased dependence on strategic suppliers. Regarding the latter, Petersen et al. (2005) regards the "lock-in" effect to a particular technology or supplier as a major disadvantage of ESI. This situation can be particularly problematic in case the buying firm needs to choose which supplier to involve early in the context of technological uncertainty.

Furthermore, it is believed that ESI increases the complexity of managing development projects (Wynstra and Pierick, 2000). In this regard, Hartley et al. (1997) believes that managing the buyer-supplier interface within ESI can complicate project coordination task and control for the buyer. Thus seen from that angle, ESI can indeed add more difficulty in the early stages of the development process, in which most of the internal resources happen to be aimed towards creating the most efficient development structure (Sobrero and Roberts, 2002).

ESI limitations	References
Resource and time consuming	Sobrero and Roberts (2002)
Loss of proprietary knowledge	Mikkola and Skjoett-Larsen (2003)
Loss of internal key-competencies	Mikkola and Skjoett-Larsen (2003)
Risk of technology spread to competitors	Mikkola and Skjoett-Larsen (2003)
Risks of "Lock-in" to supplier's technology	Petersen et al. (2005)
Increase complexity related to buyer-supplier interface	Wynstra and Pierick, 2000; Hartley et al., 1997; Sobrero and Roberts, 2002.

Table 3. 3: Suggested ESI limitations

3.7 Barriers to ESI implementation

In regard of all the potential advantages of early supplier involvement, it makes sense to assume that ESI provides a good edge to organizations practicing it. However, as shown by some empirical researches, companies do not always take full advantages of the potential of ESI. There is a misalignment between theory and practice regarding ESI benefits. Therefore, in order for companies to harness the full benefits of ESI, they should be aware of the risks and barriers to ESI implementation, and overcome those difficulties. In this section, some issues that hinder the implementation of ESI are presented.

According to Wynstra et al. (2001), difficulties in managing supplier involvement in product development, usually originates from one of the three main sources, namely: the buyer-supplier relationship, the supplier as a source of the problem and the buying firm itself.

3.7.1 The buyer-supplier relationship as a source of problems

Regarding the buyer-supplier relationship, issues such as poor communication and absence of trust are very problematic, and may eventually lead to unclear agreements and diverging expectations. For instance, major difficulties can occur when the buyer/manufacturer does not clearly explain to suppliers what their design responsibilities are. As a result, suppliers might make false assumption as to what their responsibilities are, and base their strategy on those wrong assumptions. As immediate

consequence, this will have a negative impact on the efficiency and effectiveness of the collaboration between the two parties. Moreover, with the absence of trust, each of the two parties will see large potential risks, and therefore not collaborate properly. Accordingly, it might also be difficult for the buyer to engage new suppliers particularly in situation where the buyer might need new types of competencies that he does not possess (Wynstra et al., 2001). Furthermore, opportunism is also an issue reported to affect buyer-supplier relationship under ESI (Jap, 2001). For instance, when involving suppliers early in the process, the buyer's firm exposes its knowledge to its counterparts and vice-versa. This form of collaboration can be vulnerable, if one of the parties decides to be opportunist and use the knowledge of the other to its own advantage. Another form of opportunism can be displayed by the reluctance of either the buyer or the supplier when it comes to sharing exclusive information with its counterpart (McIvor and Humphreys, 2004).

3.7.2 The supplier as a source of problems

Concerning the supplier as the cause of the issue, Wynstra et al., (2001) refers to the insufficient technical capability of the suppliers as being problematic. Indeed, the authors believe that the price-focused criteria for supplier's selection might increase the risk of the manufacturer opting for suppliers with low technical capabilities and little to know experience in joint product development. Another supplier-related problem appears when suppliers do not show sufficient commitment to building working relation with the buyer. For instance, suppliers might not be interested in committing necessary time and resources in working with the manufacturer because of the minor return in profit (e.g. share of the supplier's total sales) it will bring. In this case, McCutcheon et al. (1997) believe that this situation might yield to a difficult collaboration and potentially have a negative impact on the end result. Another reason stressed by MacDuffie and Helper (1997) is that other customers might influence the attitude of suppliers. For instance, a manufacturer will find it difficult to commit a supplier when that supplier has many other customers simultaneously asking for the same service and particularly when that manufacturer does not offer anything advantageous in return. Moreover, another non-negligible cause as mentioned by Kamath and Liker (1990) can be the fear that suppliers have of losing their key competencies from their collaboration in product development. In other words, the collaboration under ESI is often extended, and as such, suppliers are afraid of dedicating themselves too much towards a single buyer/manufacturer and end up being highly dependent on that single customer.

3.7.3 The buyer/manufacturer as a source of problems

For issues related to the buying firm, Wynstra et al. (2001) claim that complications may pop up when the buying firm does not have a clear involvement strategy and process, and as such is unable to recognise when, and for what a supplier has to be engaged. For instance, the buyer might involve the wrong supplier for certain component or might choose the wrong timing of involvement. Another issue might occur within the buyer's organization, when for instance, employees from departments dealing with supplier involvement would erect some barriers to suppliers because they feel their job threatened by the latter. Those employees' reluctance to collaborate with suppliers might be expressed during the collaboration by setting unrealistic targets or not providing enough information in order to further complicate the task for suppliers.

In line with the above-mentioned issues, McIvor et al. (2006) conducted a case study in the electronics industry. In their study, the author presented additional barriers to ESI between the studied company and its key suppliers (table 3.5).

- Playing suppliers off against one another in the design process in order to extract more favourable terms
- Lack of clarity and inconsistencies in the policy guidelines for the level of supplier involvement and the time of supplier selection in design
- Influences from corporate level can be detrimental to the management of ESI at local level
- Design personnel resistant to increasing the level of involvement of suppliers in the design process
- Conflict between members of the integrated product development team
- Perceptions of the re-design cost reduction process as being that of switching suppliers
- Suppliers are suspicious of the motives when requesting cost information
- Suppliers not confident enough of the accuracy of their costing structures to share them with their customers
- Incompatibility of systems of the company and its key suppliers
- Not enough dedicated resources to jointly work with key suppliers
- Annual contract negotiations perceived by suppliers as a barrier to effective cost improvement programs for the life of the contract
- The exercise of power by the customer in the relationship can be detrimental to effective ESI
- Culture of people in both the company and suppliers is a considerable barrier to the principles of ESI such as supply base reduction, cost information sharing and resource commitment from top management

Table 3. 4: Barriers to early supplier involvement (ESI) between the company and its key suppliers (McIvor et al., 2006)

Despite the fact that the barriers presented by McIvor et al. (2006) are relevant to the electronics industry, it is interesting to observe that they are also in line with the barriers pointed out by Wynstra et al. (2001).

3.8 Key prerequisites for successful ESI

In the previous sections, benefits, limitations and barriers to ESI adoption have been discussed. It appears that ESI is quite a broad concept that many companies struggle to practice. Moreover, with the absence of comprehensive guidelines on how to manage ESI, companies tend to adapt the ESI procedure specific to their own needs (Dowlatshahi, 1998). Nevertheless, as pointed out by many scholars, there are some key elements that if dealt with properly, can guarantee success in managing the supplier involvement process. The following paragraphs will consist in explaining each of those elements as found from the literature.

3.8.1 Trust

Trust can be defined as the confidence that a buyer firm puts on a supplier in terms of honest and responsible behaviour (Zhao and Lavin, 2012). Trust represents one of the most important aspects of a relationship. As such, authors like Morgan and Hunt (1994) believe that trust is an essential element for any fruitful collaborative relationship. It thus makes sense to believe that a lot of trust is needed when involving suppliers in NPD, particularly because NPD has a significant influence on the future competitive advantage of the firm. Moreover, NPD projects are often characterised by uncertainties and time delays combined to high failure likelihood. Nevertheless, Walter (2003) claims that trust can help mitigate or even avoid those risks by means of cooperative solving activities between trustworthy partners. Trust also plays an important role in the relationship between partners, as it allows them to no longer be worried about the leakage of knowledge or opportunistic behaviour (Inkpen and Tsang, 2005). In the same line of reasoning, Colombo et al. (2011) argues that trust is an essential element in early buyer-supplier relationship, as it facilitates knowledge exchange between both parties, although buyers still requires a certain amount of control. Regarding the latter, it is not quite anecdotic, as there are always risks of dishonesty in any relationship. Thus, Sobrero and Roberts (2002) believe it is the responsibility of the buying organization to establish cooperative norms and high level of trust with suppliers. This for the reason that involving supplier requires sharing information on product, processes, technology, and as such, it would be impossible to achieve those requirements without trust between the parties.

Another positive aspect of trust as found by Ragatz et al. (2002), is that it facilitates communication between the parties. It seems obvious that with the absence of trust, parties would be reluctant to communicate their intentions and needs.

However, one should not forget that trust does not build up overnight. Instead, trust is a lengthy process that should grow overtime between all involved parties or organizations. Thus, in buyer-supplier relationship trust needs long time to develop, but can be destroyed in an instant through opportunistic behaviour (Johnsen, 2009)

3.8.2 Communication

Communication is a key element for acquiring the product of fruitful buyer-supplier collaboration. According to Mohr and Spekman (1994), high communication quality and information sharing are linked to successful cooperative agreements. Paulraj et al. (2008) further stresses on the importance

of collaborative communication strategies in deepening trust and cooperation and engendering great performance

Many studies have pointed evidence towards the importance of communication in ESI and which added value it could bring. In this regard, Brown and Eisenhardt (1995) advocate that communication, when happening on a frequent and effective base can ease the comprehension of information and improve overall performance. Also, Hartley et al. (1997) stress on the importance of communication in facilitating activities coordination, and ensuring real time information sharing between parties.

There exists different means by which communication can happen between parties. However, face-to-face communication is considered by Wognum et al. (2002) as the most effective form of communication in buyer-supplier relationship. In this regard, the temporary co-location of supplier's staff (e.g. engineers) at the buyer's project team is frequently mentioned as an important aspect of ESI, as it enables intensive communication between both partners (Monczka, 2000)

Additionally from literatures, email also appears to be an important way of communicating. This claim is supported by Thomas (2013) who studied the effect different means of communication had on knowledge exchange in buyer-supplier relationship. From her analysis, she discovered that through electronical means of communication such as emails, it was possible to obtain the same quality of information such as in face-to-face communication. Thus she concluded that emails had a positive influence on knowledge exchange. Moreover, Thomas (2013) made a distinction between email and face-to-face communication by claiming that the latter is very practical as mediator in the case of effective NPD while email communication is very useful in information transfer. However, despite the benefit of those types of communication it is important to find the right frequency of communication in order to ensure success in ESI. In other words, how often should parties communicate with each other to ensure a smooth process?

In 2013, Yan and Dooley looked into that question through their study on the impact that the intensity of communication has on project performance. From their findings, they concluded that in case of joint NPD with high task and relational uncertainties, intensive communication had a positive impact on project performance. In contrast, they also concluded that in case of joint NPD with lower task and relational uncertainties, intensive communication had a poor effect on project performance.

3.8.3 Top management's support

Successful ESI depends upon a high level of commitment and resource allocation from both the customer and supplier organizations (McIvor et al., 2006). As such, top management provision of both financial and political resources, constitutes a key ingredient for success. In order to effectively implement ESI, a culture that encourages and values collaboration is necessary. Thus, Ragatz et al. (1997) believe that top management commitment at both buyer and supplier organizations can be very helpful in modifying and aligning the organizations' cultures for instance by guaranteeing their staffs that sharing information is allowed and that resources will be made accessible to secure the integration effort.

3.8.4 Knowledge and information exchange

Buyer-supplier cooperation is a knowledge-intensive process essential for the success of new product development (Lawson & Potter, 2012). For a successful supplier involvement there must exist a constant information flow between involved parties (Ragatz et al., 2002). Langner and Seidel (2009) believe that in order to stimulate information exchange, a firm should take advantage of the competition between suppliers in order to gather information.

Similar to communication, information exchange can positively contribute to building trust between parties, thus improve project performance.

Furthermore, sharing technology and cost information early on can be vital for the overall process, as according to Petersen et al. (2003), it enables the product development team to actively discuss which technology choice will be suitable regarding market requirements. Moreover, early sharing of technology information gives the possibility to gather external knowledge early in the process, and as such, can be very beneficial in situation of technology uncertainty (Petersen et al., 2003).

3.8.5 Long-term commitment

According to Mc Ivor et al. (2006), success in implementing ESI depends on a high level of commitment from both buyer and suppliers firms. Similarly, Eisto et al. (2010) believes long-term commitment is a good way to build trust between parties. Thus, the hypothesis according to which "higher supplier commitment leads to greater supplier involvement in NPD" wears all its significance. In this context, the key factor is to know how parties should act in order to create commitment. To this question, Eisto et al. (2010) suggest that buyer's organization can create commitment by investing in its supplier's production machines. Another way of creating long-term commitment can be done through contractual agreement. For instance, at Toyota, once a supplier has a contract for a part, the contract remains in place as long as the model is being manufactured (Kamath and Liker, 1994)

3.8.6 Formalised risks and reward sharing/ win-win situation

Humphreys et al. (2003) advocates that the willingness of both buyer and suppliers to share risks is a key factor to ESI success, as it helps develop trust and facilitates long-term commitment between the parties. Accordingly, the buyer can encourage risk sharing with its supplier for instance, by consenting to offer certain percentage of the total production volume to the supplier (Peter, 1996).

In the same way, successful ESI also depends on the formula for reward sharing between parties. In other words, collaboration should benefit to all parties and not only to a particular one. For example, suppliers should be able to sense the impact of their efforts in volume increase in terms of profit. Also, suppliers should be able to account their increased responsibilities in terms of profit (Kulmala et al., 2002). However, creating a win-win situation does not necessarily imply an equal repartition of profits (Whipple and Frankel, 2000) between partners, but instead, implies that each partners receives benefits proportional to their efforts or investments (Ring and Van de Ven, 1992)

However, sharing profits can be a task difficult to achieve, as it requires certain trust and cost transparency, for instance through open book accounting from both the client and the supplier's

side (Marson et al., 1999). In this regard, Giannoccaro and Pontrandolfo (2004) suggest allocating to each partner an agreed percentage of the total product's income

3.8.7 Customer's ability to manage supplier involvement

For the supplier involvement to be successful, it is important for the buyer's organization to be aware of which suppliers to involve and which responsibilities those suppliers should bear during the involvement. For example, giving inadequate design responsibilities to the wrong supplier might be catastrophic, as it will result in the buyer spending much effort and time to coordinate that supplier. As such, supplier involvement would no longer be useful, as the same amount of time saved with internal engineering would now be spent in communicating with suppliers (Wynstra and Pierick, 2000). In this context, Wynstra and Pierick (2000) pursue by claiming that the buyer's capacity to make a distinction between forms and stages of supplier involvement can be very useful in setting priorities in order to render the supplier involvement more economical and manageable.

3.8.8 Supplier's capability

Another key factor to success in early supplier involvement is the capacity of the supplier to cope with technological challenges. According to Squire et al., (2006), the technical capabilities of a supplier have a positive influence on the performance of a buyer's manufacturing. As such, the author believe that a supplier that possesses flexibility, responsiveness and modularity capabilities can enable a buyer's organization to improve its response speed to request from client on the marketplace. Similarly, Hartley et al. (1997b) claim that delays related to suppliers can be reduced by working with technical competent suppliers. Also the authors consider that due to their problem avoidance and problem solving skills, technically capable suppliers can speed-up the product development process.

3.9 Synthesis

In this chapter, the concept of early supplier involvement (ESI) as retrieved from different literatures has been presented. It has been shown that the term ESI has various definitions that can more or less differ per scholars and per industry. In this regard, we opt to define ESI in the Dutch infrastructure context as a form of buyer-supplier collaboration that takes place prior to the construction, maintenance and operation phase. In that sense, we stipulate that an operation and maintenance supplier consulted during the design phase or earlier project phases can still be considered as an early involved supplier.

Moreover, this chapter has shown the influence that the timing and extent of supplier involvement can have on the ESI process. From studying those two variables, some interesting conclusions can be drawn. Firstly suppliers that hold a strategic position in the project should be involved as early as possible, preferably in phases where changes will not impact the project. Also, for project requiring high degree of innovation, it is suitable to involve suppliers as early as at the incubation phase.

In figure 3.5, an attempt is made to translate the model proposed by Handfield et al. (1999) in figure 3.2 to fit the different phases of a Dutch infrastructure project.

Figure 3. 5: Timing of involvement based on the categories of suppliers in a Dutch infrastructure project

As it can be seen from figure 3.5, the more important the supplier and the more complex the item to be supplied, the earlier that supplier should be involved. Here it is important to realise that this model does not intend to answer the question *"how early should suppliers be involved?"*, as there are no clear answer to such a question (McIvor et al., 2006). In fact, the timing of supplier involvement depends on different parameters such as the nature of the project, the type of suppliers, the degree of technology uncertainty and the degree of innovation. Therefore, this model does not provide a straightforward answer, but rather advises on which category of suppliers would yield the most added values if involved earlier or later. Consequently, practices deviating from this model would not necessarily be wrong. For instance, it should not always be considered bad practice to have a

''white box'' supplier be consulted at the earliest phase of the project, despite the model advising otherwise. This somehow shows the broad aspects of the ESI concept. Consequently, on answering the question *''how is ESI implemented in other industries?'',* it is perhaps logical to say that there is not a single way of implementing ESI that is particular to a specific industry. Instead, all ESI efforts so far have been developed to meet the specific needs of particular firms, as there are currently no available standard, framework or guidelines for ESI implementation (Dowlatshahi, 1998). Nevertheless, this literature review has revealed the particular attention companies in other industries give to factors such as the nature of the project, the type of suppliers, the degree of technology uncertainty and the degree of innovation before deciding on engaging in ESI.

4 Overview of other concepts similar to early supplier involvement in the Construction industry

In the previous chapter, the concept of ESI as implemented in other industries has been explored with quite some depth. In this new chapter, ESI will be positioned within the construction industry context. This will allow a quick overview of what has already been researched in the direction of early supplier involvement in the construction industry.

4.1 Supply chain integration (SCI) in the construction industry

4.1.1 Definition and concept

In terms of previous thoughts pointing in the direction of the early supplier involvement concept in the construction industry, the concept of supply chain integration represents a good candidate. In literatures, the definition of supply chain integration varies per researchers and organizations. As such there are only few available specific definitions of the concept. This is perhaps due to the fact that, for some scholars, the concept of SCI is closely linked to the concept of supply chain management (SCM). According to Ofori (2000), the keyword ''integration'' constitutes the basic principle of SCM. In this regard, several definition of SCM highlight the word ''integration'' to emphasise its importance in the whole process.

Supply chain integration can be defined as a comprehensive collaboration between supply chain network members in strategic, tactical and operational decision-making (Bagchi et al., 2005). Romano (2003) on the other hand, sees the integration process as a mechanism to support business processes across the supply network to overcome intra and inter-organizational boundaries. Meanwhile Cagliano et al. (2006) see SCI more as a coordination mechanism in which business processes should be reorganized and interconnected both within and outside company boundaries. From those different definitions, it thus seems obvious that scholars and organizations have different interpretation of SCI. In that sense, Vrijhoef and de Ridder (2005) believe that supply chain integration is no goal in itself, but instead aims at increasing common socio-economic benefit of construction works by both increasing profitability and competitive strength of suppliers and improving the value for the client.

4.1.2 SCI approach

In previous literatures regarding supply chain integration, analyses are often performed based on three main approaches: external (with supplier and customer) and internal integration, process integration and information/data and physical/materials flows integration (Alfalla-Luque et al., 2013). In this regards, scholars such as Poirier and Bauer (2001) and Pagell (2004) advocates organization to achieve both intra and inter-organization integration across the full supply chain in order to function as a single entity. However, Cagliano et al. (2006) believes integration should first start within the same organization before being spread across the supply chain. However, it is often proven difficult for organization to achieve higher level of integration within their own supply chains. For this reason, Fawcett and Magnan (2002) recommend focusing on coordination between functions in order to achieve integration within a company's supply chain. Seen from this

perspective, SCI can be considered as a tool that serves to break down organizational boundaries between functions and barriers between organizations (Alfalla-Luque et al., 2013).

4.1.3 Benefits and barriers to SCI

In terms of benefits, many scholars recognise the importance of supply chain integration in the construction industry. According to Maqsood and Akintoye (2002), integrating the supply chain facilitates the alignment of objectives between supply chain partners, which in turn helps in achieving common goals, improving productivity and minimising waste. Similarly, Hall (2001) also sees benefit for organization initiating higher integration in terms of margins, reduced stress and aggravation, development of no-blame culture, development of mutual understanding, and enhanced reputations. However, achieving high integration within the supply chain is a difficult task, in the sense that there are many obstacles that need to be overcome.

In terms of barriers, different scholars agree on the fact that achieving higher integration is made difficult due to lack of trust, adversarial contractual relationships and continued reliance on fragmented project delivery system (Khalfan et al., 2004; Vrijhoef and de Ridder, 2005). This is particularly the case on large projects, where construction supply chains involve hundreds of material, component and service suppliers (Dainty et al., 2001b). In the same line of thinking, Akintoye et al. (2000) identifies the nature of construction project teams, lack of commitment from the top management, culture at the workplace, lack of knowledge on supply chain management and inadequate support structure as particularly problematic to achieving high integration of the supply chain.

4.1.4 Success factors to SCI

Among factors likely to generate success in achieving fully integrated supply chains, Tan (2001) advocates changes in the corporate culture, trust and communication among all the parties involved, information/knowledge sharing, suppliers' evaluation for supplier development process, and sharing common goals of waste elimination and increased efficiency. Other scholars recommend ensuring fair payments and early involvement with projects; educating the construction workforce; improving communication skills through soft skills development; knowing the operations of other type of organizations within construction supply chain; knowing the benefits of supply chain integration and partnering; understanding new contractual documents; client and main contractor organizations accepting that sub-contractors can bring added values to the construction project delivery process; developing trust between parties, particularly at key interfaces in the supply chain (client/contractor, consultant/contractor, contractor/subcontractor, contractor/suppliers, etc.) and willingness to share knowledge (Dainty et al., 2001a, 2001b)

Murray et al. (1999) on the other hand, claims that strategic partnership is the key to integration, and believe such relationship can help overcome the temporary nature of one-off project and ensure some continuity in the supply chain. Similarly, Proverbs and Holt (2000) suggest downstream strategic alliance between downstream supply chain parties (main contractors, subcontractors, material suppliers etc.). They also recommend early involvement of subcontractors and suppliers in the same way as done with early contractor involvement.

4.1.5 Client's procurement role in supply chain integration

Clients play a very central role in the integration of construction supply chains. According to Briscoe et al. (2004), the client is the initiator of procurement decisions and the way in which it takes place, and as such, the client's organization plays a critical role in integrating the supply chain. Khalfan et al. (2005) believes the manner in which of procurement is conducted can influence the integration of the supply chain, which in turn will positively affect the supply chain performance and the value delivered to the client. As such, the authors believe adopting new procurement strategies and methods can help facilitate the integration of the supply chain. Cox & Ireland (2001) share the same opinion, and see the potential for better alignment and integration of the supply chain for client who can adapt their procurement strategies vis-à-vis the market place. Moreover, McDermotti and Khalfan (2012) see the importance that integrating construction personnel in team has in terms of effectiveness and efficiency, and believe such team integration can be achieved through procurement

However, for McDermotti and Khalfan (2012), most clients in the construction industry do not have the dominant place they should have, particularly due to their lack of understanding of the market place

4.2 Early private involvement in the Dutch construction industry

Traditionally the client has imposed itself as the initiator of infrastructure projects, by taking the initiative on projects and deciding on the manner in which procurement takes place (Briscoe et al., 2004). This dominant role has increased responsibilities for the client organization throughout years, particularly in the domain of infrastructure planning.

However, as time advanced, society demands have increased project complexity, and as a result, it has become difficult for traditional planning approach to cope with project risks (De Roo, 2007). This situation has forced the industry to explore other alternatives in planning among which the introduction of public private partnership (PPP) (Wettenhall, 2003).

For the Dutch infrastructure planning, the immediate implication of those new developments was the integration of private organizations already at the planning stage, thus the designation 'early private involvement'.

4.2.1 What is early private involvement in the Dutch context?

Before giving a definition to what early private involvement is, it is important to first briefly explain the Dutch planning procedure. In the Netherlands, Rijkswaterstaat as an executive branch of the Ministry of Infrastructure and the Environment oversees the design, construction, management and maintenance of infrastructure and waterways networks (Van den Brink, 2009). Through the national framework also known as MIRT (*Meerjarenprogramma Infrastructuur, Ruimte en Transport*) plan and decision-making regarding investments in infrastructure projects are made. The MIRT process in itself consists of three distinct phases namely: the exploration phase, the plan development and the realisation phase. Usually, it is at the end of the plan development phase (after the issuance of formal planning consent), that the public client makes contact with private parties through the request for proposals. Here it is important to realise that, at this stage the preferred alternative is

translated into conceptual design (where about 30 up to 70% of the work is specified), and also at this stage, decisions regarding local land-use plan, environmental permit and route decision are already taken. Thus, the private party when brought on board is only responsible for the final design and construction (Lenferink et al., 2014). In consequence, view from that angle, early private involvement in the Dutch context can be denoted as bringing private parties on board in stages earlier than the plan development stage.

4.2.2 Forms of private involvement in Dutch infrastructure projects

In the Dutch infrastructure world, private involvement can either be pre-competitive (or non-competitive) involvement, competitive involvement and post-competitive involvement.

Pre-competitive involvement also known as non-competitive model represents the earliest category in which private parties can be involved. Here private parties are involved before procurement takes place, and as such, this category is not specified by European procurement law. Examples of pre-competitive involvement are: market consultation, early design contest, market reconnaissance and unsolicited proposal (Lenferink et al., 2014).

According to the European commission (2004), competitive private involvement is a form of contracting performed in respect of the European procurement law. This category comprises alternatives such as green procurement, competitive dialogue procedure and interweaving (Lenferink et al., 2012).

For the post-competitive private involvement, the emphasis is made on managing contracts in which private parties are involved. In this regard, integrated contracts such as Design and Construct, Design-Build-Finance-Maintain and performance contracts fall under this category.

Figure 4.1 provides an overview of the different categories and models of private involvement.

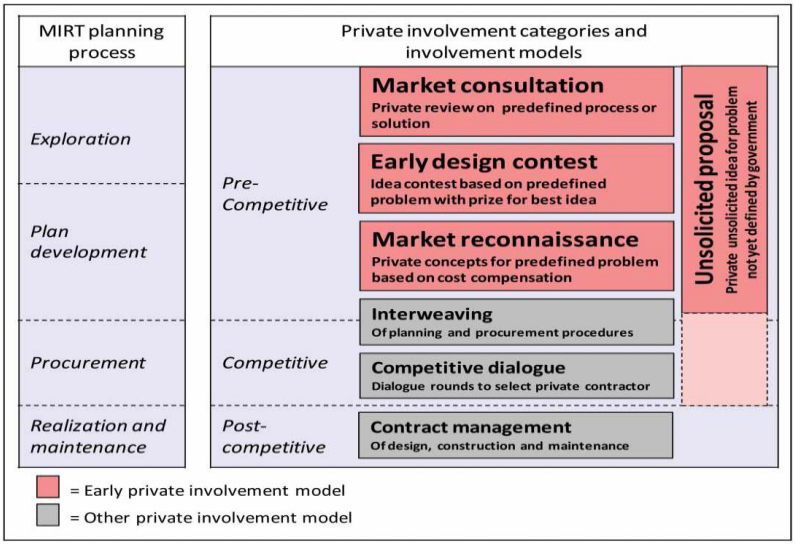

Figure 4. 1: MIRT planning process and the private involvement categories and models (Lenferink et al., 2014)

From figure 4.1, it seems obvious from the different categories of private involvement that the pre-competitive category is the one that represents what can be called early private involvement, as it takes place in early stages of projects. In the next paragraph further elaboration will be given on this latter category

4.2.3 Forms of early private involvement in Dutch infrastructure projects

As previously mentioned, early private involvement in the Dutch context, can be resumed to the pre-competitive category. In this category, different models of private involvement can be distinguished, namely market consultation, early design contest, market reconnaissance and unsolicited proposal (Lenferink et al., 2014). Differences between these models can be found in the way they are organised by the authorities, in their goal, scope and timing of implementation. In the next sections, further elaboration are provided on these models.

4.2.4 Market consultation:

With market consultation, private parties are invited to give their opinion about feasibility of technical solution developed by the government (Rijkswaterstaat, 2006). This represents an opportunity for the contracting authority to share its questions with private parties and see whether they can come up with innovative ideas. As such, this model allows the contracting authority to take advantage of the innovative capability of the market. This model of involvement is usually applied in Dutch planning practice, and does not stipulate any obligations for contracting authority and private parties. The consultation in itself can be open for all entrepreneurs or restricted, interactive or active, oral or written.

In terms of benefits, market consultation is interesting for private parties for the only reason that it allows them to be aware of the process and intentions of the contracting authority early (Lenferink et al., 2014). However, with market consultation, private parties have a passive role, and there are no prize rewarding the best solution or no reimbursement of cost. As such Lenferink et al., (2014) believe that some improvement must be made with this model, particularly in terms of incentives for creativity otherwise the risk for strategic behaviour would be too high. In the same line of thinking, Witteveen & Bos (2010) recommends to minimise transaction costs because of the non-reimbursement of cost that comes with this model.

4.2.5 Early design contest:

During early design contest, private parties are challenged by the contracting authority to come-up with innovative solutions. This is done through a notice where private parties are invited to take part to the contest. The quality of the design is anonymously assessed by a jury, then an opportunity for dialogue between participants and jury is given. Following the dialogue, the final decision is communicated. In itself, the design contest takes place based on the request for proposal formulated by the contracting authority, in which both problems and preconditions are defined.

Particularities of the early design contest is that participants are incentivised to provide the best solution through price reward, and the intellectual property right remains with the private parties, allowing them to reuse their patented solution in other projects. On the other hand, in order for the

contracting authority to obtain the license to use the patented solution, royalties should first be paid (Van der Burg & de Groot, 2009).

However, the main concern with this model regards the jury judgement, as this can be a source of uncertainty for private parties

4.2.6 Market reconnaissance:

This is a model similar to early design contest, but this time without prize to reward the best solution. With this model, the government defines the problem, the scope, the goal and constraints, and based on those requirements, the government expect from private parties to come up with technically and financially feasible concepts, and in return, private parties are compensated for their engineering costs. Although the model is typically Dutch, it has only been applied on very rare occasions in The Netherlands. This was for instance the case on the Afsluitdijk Renewal Market Reconnaissance that took place between April 2008 and March 2009 (Rijkswaterstaat et al., 2009).

In market reconnaissance, the contracting authority does not select the best solution, but instead can make use of all generated ideas during the process. Unlike market consultation and early design contest, this model requires a high transaction costs, as both contracting authorities and private parties often engage in extensive dialogue (Lenferink et al., 2009) and perhaps also because participating private parties are often made of large consortia.

4.2.7 Unsolicited proposal:

In this model, the initiative lies with private parties who engage government without invitation regarding an idea, a proposition or a developed plan (Kroes, 2008). Through this form of involvement, the government can use private sector idea or proposition to develop the contour of a project. One aspect of this model is that it requires private parties to have sufficient insight into public planning procedures. Another contrast in this model compared to other discussed models is that, here private parties have a more pro-active role and take the initiative. The contracting authority on the other hand is passive and is often reluctant to accept solution from private parties, which in itself limits the opportunity for public-private collaboration (Lenferink et al., 2014).

In table 4.1, a brief overview of the different characteristics of the discussed model is presented.

Model	Market consultation	Early design contest	Market reconnaissance	Unsolicited proposal
Goal	Opinions on government solution or process	Best design for defined problem	Conceptual solutions for defined problem	Ideas without a predefined problem
Scope and concreteness of project	Related to specificity of government solution or process	Limited scope, usually specific	Broad scope, not specific	Depends on character of proposal
Reward for participation	Information for future procurement of a project	Prize and publicity	Cost compensation	Future procurement of a project
Incentive for creativity	No specific incentives besides reward	Future procurement of a project Patented solution	Future procurement of a project Publicity	Intellectual property rights protection
Setup	Plenary meeting with possible one-to-one follow-up	Contest with possible plenary kick-off meeting	Dialogue rounds and staged selection process	"Post-box" for private proposals

Table 4. 1: Characteristics of early private involvement models (Lenferink et al., 2014)

Part III: Empirical research

5 Data collection and analysis

This chapter explain the method used for data collection and analysis for this research. First general information about the interview is given. Then criteria for interviewees' selection are presented. Next the process of conducting the interview is briefly explained. The remaining section of this chapter gives an overview of the qualitative analysis technique used for the data analysis.

5.1 Interview set-up

Empirical knowledge was gained by consulting experts through interviews. First round of interviews were performed with 4 respondents selected based on their knowledge or experience in relation with the topic. This was done in order to gather more general information and steer the research on the right direction. The idea was to have their perception and insight on the idea of applying the ESI concept, and to verify whether or not ESI was already being implemented in Dutch infrastructure projects.

Next, the second round of interviews was organised with the remaining 10 participants and the emphasis was made on key ESI aspects, as learned from literatures and first round interviews. Interviewees were questioned on key aspects important to achieve success in ESI. This was purposely done to gain insight into what has already been achieved so far, and what could still be improved. At time, interviewees were asked to answer questions regarding their overall project experience or regarding specific projects where early supplier involvement had more or less taken place.

In total 13 interviews regrouping 14 respondents were conducted, with 3 of those interviews used as background information. From the 14 respondents, 6 worked for the client organization, 4 for the contractor's and 4 for the supplier's (see table 5.1). Prior to each interview, a 'request for interview' email was sent to potential respondents. In the email, a brief overview of the topic to be discussed during the interview was given, in order to prepare the interviewee for what to expect.

5.2 Interviewees selection

Keeping both the objectives and research questions in mind, interview participants with different backgrounds were personally invited to take part in the interview. Given the research topic at hand, the aim was to interview professionals from different backgrounds within the Dutch infrastructure sector. As such, there was quite some flexibility in the selection criteria, although the core criterion was for interviewees to be member of one of the stakeholder group client, contractor and supplier. However, a preference was given to respondents based on their knowledge and expertise in procurement, contract management, supply chain management and their experience with large infrastructure projects. Regarding the latter, some key large infrastructure projects were selected as criteria, and a preference was given to interviewees involved in one of those projects. An exception to this latter criterion was made to first round interviewees selected for more background information.

The decision to select respondents with those different backgrounds was intentionally made in order to ensure some diversity in the responses. In other words, given the difficulties to find documents

regarding ESI in the Dutch infrastructure sector, it was necessary to have inputs from different perspectives, and not limit myself to a particular group or function.

5.3 Conducting the interview

A semi-structured and in-depth interview approach was selected as data collection method. The interview questionnaire was organised in sets of background question and open-ended questions within which some leading questions were included. Those leading questions served as guideline, and depending on the interviewees' answers, questions were either adjusted or some additional questions were asked. For some questions that interviewees couldn't answer, they suggested interviewing other knowledgeable people (snowball sampling). The interviews were audio-recorded then transcribed verbatim into extended text. Later on, the interview transcripts were sent back to the interviewees for verification and validation, and to ensure that the interviewees' opinions were fairly and consistently transcribed. Then, the coding process of the interview transcripts could start, as shown in the following section.

Codename	Function/Role	Organization
#1	Contract manager	Client
#2	Contract manager Technical manager	
#3	Technical manager	
#4	Program manager	
#5	Intention manager	
#6	Department manager Supply chain	Contractor
#7	Procurement and subcontracts manager	
#8	Director system integration and technique	

#9	Director infrastructure tenders	
#10	Managing director	Supplier
#11	Director Operations	
#12	Procurement manager	
#13	Executive vice president	

Table 5. 1: List of interviewees

5.4 Data analysis

In general, two types of data can be collected (Saunders-Smit, 2017):

- Qualitative data: data collected by means of observation of the environment of interest such as texts, photos and people
- Quantitative data: numerical results of measured or simulated variables from surveys, experiments, etc.…

Given the formulation of my research and sub-research questions, qualitative data were collected. According to Boeije (2005), analysing qualitative data can be resumed in three stages, namely: organising interview data into categories, labelling those categories, and then finding relationships between the different fragments regarding the main research questions. For my data analysis, all interviews transcripts were coded with the software MAXQDA. The coding process followed the same structure as indicated by the grounded theory approach, namely open coding, axial coding and selective coding.

5.4.1 Open coding

The starting point of my coding process consisted in skimming the interview transcripts in order to have an overall overview. Then each individual transcript was read a second time, but now in a more thorough way. At this stage, I did not have any predefined categories for my coding. Thus, I started labelling (coding) every interesting piece of information into broad categories. This resulted in 415 open codes. (see figure 5.1).

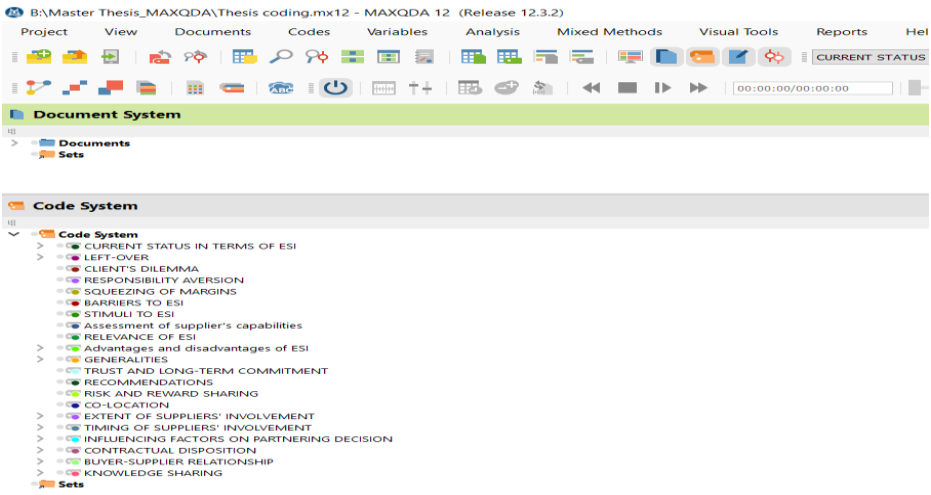

Figure 5. 1: overview of code systems after free coding with MAXQDA

5.4.2 Axial coding

Following open coding, axial coding built upon the different open-coded fragments. At this stage, thanks to the functionalities offered by MAXQDA, open-coded fragments were compared with each other and per interview transcript in order to find some relationship between those. In this regard, the code system was reorganised, and some categories were either removed or downgraded into subcategories, and the process was repeated multiple times. This tremendously reduced the total number from 415 open codes to 307 regrouped within 11 categories, as depicted in figure 5.2.

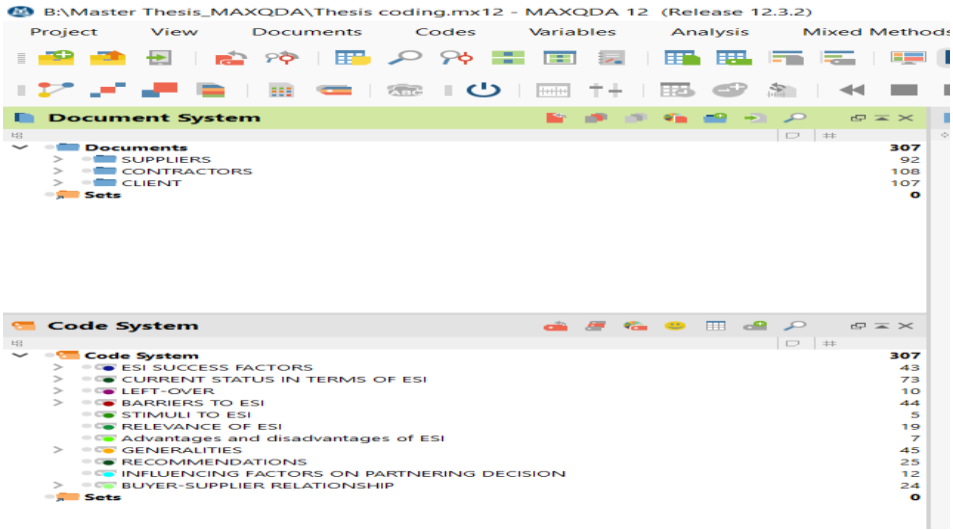

Figure 5. 2: Overview code system after axial coding with MAXQDA

5.4.3 Selective coding

Finally following the axial coding, the selective coding was performed. Here all categories were closely looked at, and some of those categories were selected as core category. Then axial-coded fragments and their respective open codes were compared with each other and combined into one of those core categories, in such a way to form a pattern that will best display the findings from the interviews (see figure 5.3). The result of this process is presented in the next chapter research findings.

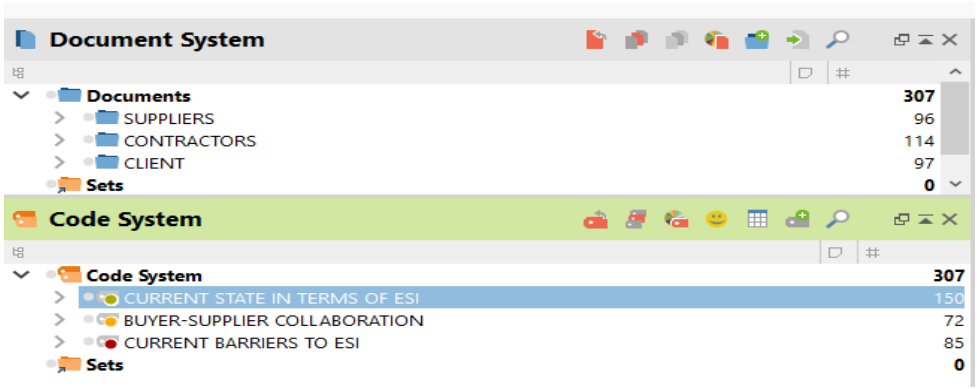

Figure 5. 3: Overview code system after selective coding with MAXQDA

6 Research findings

This chapter presents the results of the interviews as retrieved from the coding process. For presenting the research findings, quotes from respondents are used, and respondents are sometimes organised in stakeholder groups, in order to ensure their anonymity. In total 8 organizations and companies took part to the interviews, among which 2 where representing the client, 3 the contractors and 3 the suppliers. The aim here is to answer the third, fourth and fifth sub research questions: *''what is the extent of suppliers' involvement in Dutch infrastructure projects?''*; *''what are the barriers and stimuli to successful early supplier involvement in Dutch infrastructure projects?''* And *'' which key project-aspects can justify involving suppliers earlier?''*

6.1 Current state of early supplier involvement in Dutch infrastructure projects

6.1.1 Familiarity with early supplier involvement and drivers to its adoption

Prior to addressing topic-related questions during the interview, the opportunity was given to participants to give their definition and understanding of the word ''supplier''. When asked about their definition and understanding of the word, respondents yielded quite different results. All definitions given by interviewees were quite correct, however, striking differences appeared in the understanding they had of the term itself. Some respondents strictly assimilated suppliers to producer of material goods (#3, #4, #7), while others considered suppliers as an entity capable of providing goods and services (#8, #12). Eventually, other respondents further stressed their understanding of the word by assimilating contractors and subcontractors as suppliers (#5, #9). Thus, the choice was made to provide a definition that would be used to guide the remaining of the interview.

In the process of finding out the current status of the Dutch infrastructure sector in terms of ESI, the first interview questions targeted the interviewee's degree of familiarity with ESI and their understanding of the term ''early supplier involvement''. When presented with those questions, some interviewees more or less described it as ''getting the right kind of expertise aboard in early stage of the project'' (#1, #4, #5, #7), others linked it to risk reduction at early stages of project (#3) and early contractor involvement (#9). Respondent #8 on the other hand declared:

''we used this way of working without knowing that it is a concept broader in use in other industries. So I am familiar with involvement of suppliers, but not under the label as you put it in your thesis (ESI)''.

Those responses somehow indicate that the Dutch infrastructure sector is quite familiar with the practice of bringing suppliers on board in early stages of the project. During the interviews, it has been interesting to realise that the decision to involve suppliers early was not conditioned by the client, but instead was a strategic decision made by contractors in order to increase their chances of winning projects, as acknowledged by all respondents. It thus becomes intriguing to understand this increasing reliance on suppliers' expertise. In fact all contractors' respondents recognised the fact that their organisation could no longer do everything on its own, and as such needed other parties' expertise. This can be explained by the fact that due to the last economic crisis, contractors' organisation have been obliged to cut-off some of their subsidiaries, or fire many employees,

resulting in smaller organisations, as explained by respondent #7. As such, contractors nowadays no longer possess all the required in-house capabilities to conduct complex projects on their own.

Moreover, prior to a project, contractors often look for strategic partners to joint effort with. Those strategic partners are mostly other contractors who possess key capabilities that the other does not have (#6). This may look like reasons not for involving suppliers early. However, for a contractor who does not wish to have too much dependency on the other contractor during the partnership, it is believed relying to key suppliers can often be the solution.

Another triggering factor can be found in the client's attitude. Indeed, client such as Rijkswaterstaat have renounced on having full responsibilities in projects. However by raising particular questions during tender, the client has been able to indirectly stimulate awareness on the need of more optimised solutions from contractors' side (#1). Moreover, when confronted with the question on whether or not early supplier involvement was being implemented as part of the client's requirement, respondents unanimously rejected the influence of the client in that decision. Instead, they justified involving suppliers early as a strategic decision necessary in order to provide better and efficient solutions for winning project tenders. This somehow indicates the effectiveness in the way the client stimulates ESI without explicitly prescribing it.

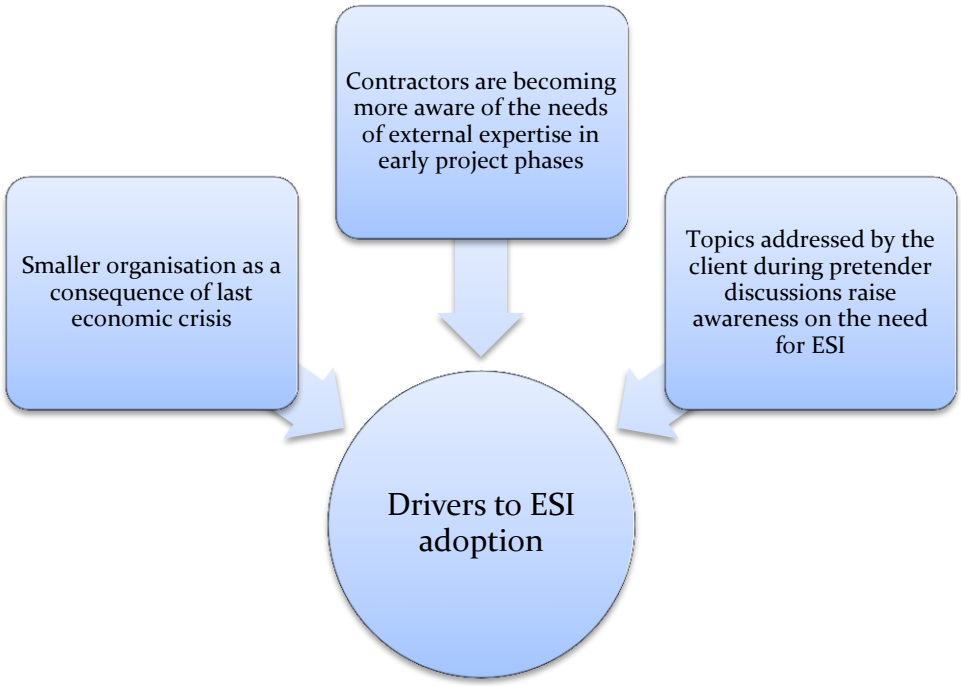

Figure 6. 1: Drivers to ESI adoption in the Dutch infrastructure sector

6.1.2 Relevance of early supplier involvement

There are several reasons that can justify involving suppliers early in Dutch infrastructure projects. According to interviewee #12, ESI is relevant for project where there is sufficient space for development. In contrast for project implying standard solutions, he believes it is better to involve suppliers in later stages. Respondent #7 and #13 on the other hand believe ESI to be more relevant for complex projects. Interviewee #9 believes it is relevant to involve suppliers early in project for strategic reasons. For instance, if within project scope there is a part that only a specific party can provide, it is then smart to involve that party as early as possible (#9).

Respondent #8 on the other hand, identifies the aspect of time as a reason for using ESI. For example, he believes that for project requiring short design and execution time, involving suppliers early can be very beneficial.

For respondent #2, ESI is less relevant for 'one-off projects', and more relevant for parties who desire certain continuity in the working relationship.

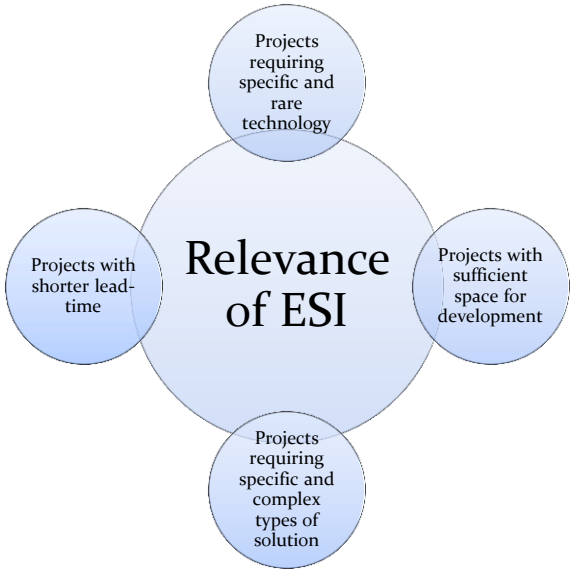

Figure 6. 2: Relevance of ESI

6.1.3 Timing of supplier involvement

The timing of supplier involvement refers to the phase from which the buyer actually starts to look for adequate suppliers and make them mindful of the project (McIvor et al., 2006). In terms of timing of involvement, respondents have reported supplier involvement during market consultation, competitive dialogue, proposal phase, design and engineering phase. In order to ensure some uniformity, those stages have been organised into two categories, namely the pre-tender phase and the tender phase.

Regarding supplier involvement during the pre-tender phase (#2, #3, #4, #9, #12, #13), respondent #13 reported their early involvement to being closely related to the complexity of the project and the required degree of innovation at stake. Thus the link can somehow be established between how early a supplier is involved and the importance of that supplier for the project. This is somehow in line with Wagner and Hoegl (2006) who claimed that the more a project is complex and requires knowledge input at the beginning of the project, the more required will be the involvement of suppliers at early stages of the project.

Moreover, according to respondent #13, this early involvement could either be a formal or informal arrangement between parties, and is done in order to discuss different options and potential solutions. For contractors' respondents, supplier involvement at the pre-tender phase is motivated by the fact that through 'route decision', contractors can know in advance what type of project will be coming to the market, as such, it gives them the possibility to evaluate what will be required for the project and allows them to make strategic decision on which supplier to involve. In this regard, a ''gentleman agreement'' can be made with a key supplier prior to the project tender, as reported by interviewee #9.

Similarly, client respondents reported involving their 'preferred supplier' years in advance prior to the tender phase, in order to prepare the project plan or give advice on elements to be put in the contract (#3, #4). One could argue this stage to be assimilated to the ''idea generation phase'' which is the earliest possible involvement phase according to Handfield et al. (1999).

At occasions, suppliers are also involved during market consultation and competitive dialogue (#2, #12). This is done in order to have market inputs on possible solution in regards of the specifications. In this regard, suppliers can take part to these discussions as part of a consortium or joint-venture. This finding is somehow consistent with the description of stage 2 of the model given by Handfield et al. (1999) which is the phase during which the technical solution that will be appropriate for the client's requirements is evaluated

During the tender phase, suppliers are reported to be involved for making the proposal or for the design phase (#6, #8, #10, #12, #13). Supplier involvement at this stage is often done when the project does not require new or innovative solution, as pointed out by respondent #13.

Although not contradicting, those findings show some slight differences with the different stages of supplier integration proposed in the literature by Handfield et al. (1999) (see figure 3.1). That difference is illustrated by the fact that the model proposed by Handfield et al. (1999) indicates supplier integration throughout every single stage of the new product development cycle, while the results from the interview limit supplier involvement to the tender phase at the latest. This can be explained by the fact that the questions addressed to interviewees asked them to recall *how early they had involved or had been involved in infrastructure project*. As such, the responses strictly portrayed the earliest stage they had ever been involved in project, which in a sense differs from the model of Handfield et al. (1999) (see figure 3.1) that only shows the different possible integration points. In a sense, those differences do not bring any conflict, as according to Petersen et al. (2005) supplier involvement is possible in every phase of the project, and there are no exact formula regarding the timing of involvement.

Overall, the interview results regarding the timing of involvement are quite consistent with the literature. Through the different stages of involvement and the reason given by interviewees, it can be recognised that the earlier suppliers are involved corresponds to how important their input can be for the project.

6.1.4 Extent of supplier involvement

In general, the range of supplier involvement can go from inputting minor design suggestion up to holding full responsibilities for complete development, design and engineering of components or system to be supplied (Wynstra et al., 2000). The model presented by Handfield et al. (1999) identifies four categories in terms of responsibilities given to suppliers during early involvement:

- **No involvement:** suppliers are only required to follow the instructions and design from the buyer's organization (client/contractor), they do not bring on any additional input.

- ''**White box**'': suppliers are invited to discuss about specifications/requirements. However, the design and specification decisions belong to the buying organization.

- ''**Grey box**'': the buyer together with the supplier get into an informal, or sometimes a formal combined development effort, which could consist of sharing information and technology and joint decision making with regards to design specification.

- ''**Black box**'': the supplier has full responsibility on the design based on the buyer's performance specifications

When presented with the categories of supplier involvement as adapted from Handfield et al. (1999), respondents identified one or many of those categories as part of their project routine. Overall, all four categories have been recognised throughout the course of the interviews. Some respondents (#7, #12, #13) strictly assimilated supplier responsibility to delivering goods (''no involvement''). This is stressed by respondent #7 who declared during the interview and I quote:

''for the ground work, it was "no involvement", so we just prescribed we need this and they deliver it''.

In terms of proportion, a majority of respondents (#3, #5, #6, #7, #9, #11, #12, #13) indicated the level of supplier responsibility as advising in writing project specifications, and giving quotation for materials or known solutions (''white box''). This somehow indicates a high reliance of the infrastructure sector on consultancy works. This can be explained by the fact that in complex Dutch infrastructure projects, contractors mostly form a consortium or joint venture with other parties that can bring key knowledge they do not possess. As such, what are remaining are more or less common goods that can easily be obtained from the market. Therefore, the contractor will contact suppliers as early as possible for giving quotation, or providing advises.

Regarding the next level of involvement (''grey box'') some respondents (#3, #7, #8, #9, #11, #12, #13) indicated taking part to joint development with the contractor or supplier.

For the highest level of involvement, in occurrence the ''black box'', interviewees #3, #4, #7, #8, #9, #12 acknowledged giving or being given full design responsibility on certain parts of the project. In

this situation for example, the contractor transfers the functional specifications (as received from the client) to the supplier who is given full responsibility on the design. This pattern is confirmed by respondent #9 who stated:

''Regarding the "Black-box" approach, what happens is that we push the functional requirement to the supplier, they make the design, but the design comes off course back and we check it''.

Another interesting finding regarding the level of involvement, was that suppliers of project aspects such as phone network, tunnel installations, were all linked to higher level of involvement, i.e. ''grey box'' and ''black box'' category. This is probably because currently in the Dutch infrastructure sector, contractors do not possess sufficient knowledge regarding those key project aspects. Therefore, they often have to involve key suppliers to manage those parts of the project. Depending on the complexity of the part, supplier can either work together with the contractor or have full responsibility on the design of that part. Another possibility is that the client can decide to standardise a part of the project to a preferred supplier. This is for example the case with KPN who is a ''black-box'' supplier of Rijkswaterstaat for all tunnel phone installations. As such, KPN has full responsibility on the total network of Rijkswaterstaat.

Another interesting finding appeared when questions were specifically asked to two supplier interviewees (#12 and #13) regarding whether or not they were satisfied with the level of responsibility they often got in project, and whether or not they would accept more responsibilities even if it meant taking more risks. All two suppliers recognised issues with lower level of responsibilities (''no involvement'' and ''white box''), however, they both showed some willingness to take on more risks and responsibilities, provided that the reward is proportional to those. This somehow indicates that given the right amount of incentives, suppliers could step forward and take on more responsibilities

6.1.5 Standardisation and use of supplier's knowledge

In terms of involving suppliers in infrastructure projects, the increase reliance on supplier knowledge has been acknowledged by many interviewees. Suppliers have become very important in Dutch infrastructure projects, and some of those suppliers even have a position of choice in projects, which is for instance the case with suppliers of road signs and phone installation in tunnels. This claim is supported by respondent #1 who declared:

''the road signs are all part of the NBD (Nederlandse Bewegwijzeringsdienst), so every contractor who is working on our Rijkswaterstaat project and who is having to put up signs has to buy the signs at the NBD. Now the same thing applies for the phone in the tunnel, where every contractor has to buy it by KPN. So we obligate our contractor to use KPN. He is not allowed to see if he can get it cheaper at tele 2 or any other phone networking company, he needs to use KPN because we have a service contract with KPN''.

It therefore appears that the client Rijkswaterstaat has standardised on NBD and KPN for all road traffic signs and phone installation within projects.

Additionally, regarding standardisation, interviewees #3 and #4 have reported the will of Rijkswaterstaat to standardise even more project components. As pointed out by interviewee #4, CIV (Centrale Informatie Voorziening), as the ICT branch of Rijkswaterstaat, is currently busy to *''manufacture and deliver way more standardised ICT components to the civil project''*. The need for Rijkswaterstaat to further standardise is motivated by the following reasons:

Firstly, interviewees recognised that standardisation is necessary in order to reduce complexity and interface problems. For instance, taking the example with KPN, interviewee #1 admitted that imposing KPN as preferred supplier helped reduce all kind of interface problems that would have emerged if every contractor would have brought its own supplier for tunnel installation. This motivation is supported by respondents #4 who stated:

''all the standardised components, if they are the same, they are much easier to maintain when we've got 30 or 40 different components. It's much more expensive to maintain 30-40 different components than for example 200 standardised components of the same type''.

Furthermore, standardisation is also used as a mean to reduce costs and increase their learning curve, as pointed out by respondent #4 *''it's easier to gain knowledge about the component when you only comprehends how it works when you only need to learn about one component than 30 different components…When something goes wrong, you only have to fix it once, and then you can deliver that solution to 30-40 other places, than when something goes wrong and you have to repair 30 different components.''*.

Another reason for applying standardisation, particularly with ICT components comes from the bad experience the client Rijkswaterstaat has had with main contractors in project. At that time, main contractor did not possess the in-house capability to manage ICT components. As such, they always employed sub-contractors to do that job on their behalf, and because they (main contractors) did not understand ICT, it became difficult for them to manage those subcontractors, which resulted in problems with the project (#4). Therefore, Rijkswaterstaat needed to step-in and *''gain more control over the ICT components that are used in the project''* (#4). Thus standardisation can be seen as a strategic decision taken by the client to ensure a smooth project process.

However, it seems interesting to realise that those standardisations are targeting more ICT components such as road traffic signs, tunnel installation and tunnel automation. Therefore, one can rightly wonder why the same is not applied to other project components let's say such as concrete for example. When confronted with that question, interviewee #4 claimed that the decision not to do so was made by the other branch of Rijskwaterstaat responsible for civil project in order to give sufficient flexibility to contractors. Moreover, he further explained that that decision was also motivated by the will of Rijkswaterstaat to stay away as possible from solution, thus reducing its responsibility in case something would go wrong.

Although not explicitly mentioned by respondents, One could argue that the client is standardising more on ICT components compared to any other component because those ICT parts are subject to fast technology advance. As such, the client has to ensure some kind of uniformity regarding those aspects; otherwise project coordination could become more complex than needed.

6.1.6 Recognised benefits and limitations of early supplier involvement in Dutch infrastructure projects

According to interviewee #12, implementing ESI, gives the possibility to access new technology and new ideas that one was not aware of. Indeed the client/contractor is not always aware of all technological developments that are taking place on the market. Thus with ESI, the client/contractor can gain insight into latest technologies and new ways of working. Van Echtelt et al. (2008) provided similar findings regarding the benefits of ESI.

Moreover through ESI, it is also possible to reduce complexity (#12) and increase predictability (#11). For respondent #13, ESI gives the possibility to bring more innovative solution to the project. Respondent #9 on the other hand believes that involving supplier earlier makes it easier to apply changes at limited cost. He is further supported in that idea by respondent #11 who states:

"it is generally understood that a change early in the project will cost 1 dollar and the same change in the middle of the project will cost 10 whereas the same change after the project is complete will cost 100. This for me is the reason for early involvement".

Another advantage of ESI is the speed in the design and the opportunity to "learn from each other" as pointed out by interviewee #8. Respondent #7 sees more the possibility of bringing smart solution to the project, as a big advantage of ESI. Interviewee #10 resumes the benefits of ESI as follow:

- Involvement and acceptance by the users / operators of the process control & automation system.
- Avoids surprises (and limits changes) during project execution or after the process control & automation system has been delivered.
- Savings on OPEX and CAPEX
- Improved production (higher efficiency, better deployment of the process control & automation system).

Those findings correspond to the ESI benefits in terms of cost reduction, time saving and quality improvement recognised by the studies of Wynstra et al. (2001), Wasti and Liker (1997) and Ragatz et al. (2002)

However, another benefit that was not mentioned by interviewees but that I would suggest is the importance of ESI in facilitating the standardisation of project component. Indeed, referring to the example taken in the previous section, the client Rijkswaterstaat has been able to standardise all tunnel phone installation on KPN. This would never have been possible without the skills from KPN's staff.

Regarding the ESI limitations, respondent #8 believes the main disadvantage of ESI resides in the risk of being ''locked-in'' to a particular supplier. As such, interviewee #8 believes it can prevent looking for other potential better option. Similarly respondent #7 also attributes the risk of being stuck with the wrong supplier as a major drawback of ESI. Those answers can be explained by the fact that in the Dutch infrastructure sector, there are very few parties which possess key technology. In fact the infrastructure world is developing at a lower speed compared to other industries such as automotive and aerospace. Therefore, when involved with a supplier possessing such key technology, one can be tempted to exclusively rely on that supplier even for project where they do not represent the best option. Consequently, the risk of being stuck with the wrong supplier is also recognised as a limitation of ESI. These findings are well in line with the results from Petersen et al. (2005)

Another limitation attributed to the ESI is the increase difficulty in managing projects due to the interfaces resulting from ESI (#1 and #9). Indeed, through ESI, organisations with different culture work together and on occasion even merge project teams. Sometimes those merged teams are composed of people with different function and background. This off course creates lots of interfaces that complicate project coordination, as confirmed by the study of Hartley et al. (1997).

Nevertheless, one could wonder why the risk of knowledge being leaked to competitors was not mentioned as a disadvantage of ESI by any respondent. This is perhaps because in the Dutch infrastructure sector in particular, most project participants are more or less in relation with each other. For instance, project partners of today can become project competitors the next month or year. Therefore, organisations are aware of the fact that if they leak information from one party to another, they will be out of business, because they will no longer be trustworthy (#7).

Benefits	Limitations
Access to new technology and ideas	Risk of "lock-in" to a particular supplier
Reduction of complexity	Risk of being stuck with the wrong supplier
Increase predictability (avoid surprises and limit changes)	Increase complexity due to buyer-supplier interfaces
Gives the opportunity to learn from each other	
Bring more innovative and smart solution	
Apply changes at limited cost	
Speed in design	
Learning from each other	
Cost reduction (savings on OPEX and CAPEX)	
Improved production	

Table 6. 1: Recognised benefits and limitations of ESI in the Dutch infrastructure sector

6.2 Buyer-supplier collaboration during early supplier involvement

6.2.1 Selection, assessment of suppliers capabilities and contractual dispositions

As previously mentioned, prior to a tender, contractors often have the possibility to know upfront which project is coming. It is within that period that the strategic decision regarding which supplier to bring on-board is made. As confirmed by many interviewees, the procedure for selecting suppliers is similar to the normal procurement procedure. Basically, the selection procedure consists in assessing two to three suppliers based on known information about the project. Past performance in other projects, financial strength and qualification for the project scope are often used to

differentiate candidates (#6, #7, #8, #9). After negotiation are completed and the supplier is selected, both parties make a sort of ''gentleman agreement'' regarding the incoming project. The ''gentleman agreement'' is a non-legally enforced arrangement in which parties commit to working with each other. At this stage, parties often agree on risk and reward distribution. However at certain occasions, this agreement can be source of problems as reported by some interviewees (#7, #9), and thus will be discussed later.

Next to the ''gentleman agreement'', there is also a Non-Disclosure Agreement (NDA) signed by both parties. According to all interviewees, NDA is a common practice of client, contractor and suppliers in the Dutch infrastructure sector, and is mainly used to prevent leakage of key information to competitors. This disposition is often taken by contractors and suppliers for the reason that after making a ''gentleman agreement'', parties must commit to each other in order to win the tender, which often means sharing key information. As such, because there is no guarantee of winning the project or further collaborating after the project is won, NDA is used to ensure that parties could just walk away or even find new partners without worrying about the knowledge they shared (#8). However, the timeframe of those NDAs can be subject to issues, as reported by respondent #10 in these words:

''*Sometimes those NDA ask us to guarantee that the information is not being leaked or shared with others for a period of more than 25 years. However in 25 years, people and companies can change, so it is almost impossible to safeguard such agreement, and that is the biggest problem*''.

Similarly for interviewee #12, an NDA does not provide all necessary guarantees, because of the penalty clause included in most NDAs. Thus opportunistic people could just leak information and just pay the penalties.

In contrast, when the project is won and parties wish to continue their collaboration, they enter in a more formal agreement which can last depending on the project duration and scope of work (#12, #13). That agreement is often called the Enterprise Framework Agreement (EFA), within which everything that can occur in the project including changes and commercial impact are laid down (#10). EFA is being adopted by many companies in the infrastructure sector; however, other companies judge the EFA too costly and therefore prefer other forms of contract with their suppliers (#6, #8). This is confirmed by the interviewee #6 who declared:

''*Three years ago we had enterprise framework agreements (EFA) or agreements with suppliers where we described this type of relationship, but three years ago we left this concept. Because it was financially a lot of efforts to keep this relationship going and it didn't bring advantages to our industry*''.

In the collaboration between Rijskwaterstaat and KPN, a framework agreement called RAAM is used. The contract length is 10 years, and depending on good performance, the contract is renewed for one year, after which, a new tender is issued (#4). The performance of the supplier in this case KPN, is assessed as mentioned by respondents #4:

'' We have KPI with them. For example, the best way to monitor is the up time of the network for instance, so if the network is 98% up, they deliver us good service, and if it's lower than that…so that's how we measure that".

Another method used to check whether suppliers are still capable of delivering what they promised is by auditing suppliers (#1, #2).

6.2.2 Working relationship between buyer and supplier

Buyer-supplier relationship in the Dutch infrastructure world can be divided into three types of relationships: the client-contractor relationship, the client-supplier relationship and the contractor-supplier relationship. Given the scope of the research, the interview focused more on client-supplier relationship and the contractor-supplier relationship.

Almost all interviewees agreed on the importance of having long-term relationship with suppliers of strategic items and maintaining arm's length relationship with suppliers of common goods. This can be explained by the fact that, most contractors have thousands of suppliers in their supply base. As such, it becomes important to segregate in terms of importance, with which suppliers efforts will be put or not to keep the relationship going. In this regard, lower tier suppliers are often kept at an arm's length relationship, because the products or services they supply can easily be obtained on the market (#6).

Furthermore, respondents acknowledged merging project teams and working at the same temporary project location. This way of working is particularly applied during the tender phase, where parties need to work together (#12). However, past the tender phase, and depending on the level of responsibility and scope of work, suppliers often end up working on their own in separate locations, as reported by interviewee #12. In addition, technology advance also constitutes another reason for buyer and supplier not to work in the same project team and location. For instance, *''virtualization and Cloud solutions and IT infrastructure / communication are diminishing the need for co-location"* as reported by respondent #11.

6.2.3 Trust and long-term commitment

According to Inkpen and Tsang (2005) trust plays an important role in the relationship between partners, as it allows them to no longer be worried about the leakage of knowledge or opportunistic behaviour. In this regard, parties often dedicate some effort in assuring their partners that they can be trusted.

When addressing the question on how parties ensured trust and long-term commitment with their partners, respondents yielded quite different answers. Respondent #12 for instance, reported that their way of ensuring trust and long-term commitment with the contractor, was by fixing (on their own expenses) any problem that could occur during operations and maintenance phase. For respondent #10 on the other hand, ''reference visits'' are used to show their commitment and trustworthiness to their client. Basically, a ''reference visit'' consists in sending your new customers to your previous customers, and let the latter present your competencies to the new one. The importance of a ''reference visit'' has been pointed out by respondent #10 in the following quote:

''From experience, this is 10 times more powerful than making long stories about commitment and so on, because everybody has nice stories on its internet site'',

Furthermore, the influence of the top management in ensuring commitment of their staff is also highlighted in the interviews. According to interviewee #10, this is done in the form of ''gentleman agreement'' between top executive of customer and supplier organisation. Respondent #10 believes this commitment at the top level has a positive influence on indirectly stimulating the commitment of lower rank employees. Moreover, respondents #10 and #11 admitted using open-book accounting as a mean to demonstrate that they could be trusted.

Respondent #9 in contrast claimed the difficulty to commit to a specific supplier, particularly at the pre-tender phase where there are still lots of uncertainties.

In a sense, those findings tend to indicate that some efforts are made to ensure trust and long-term commitment during early involvement. However, there are some other elements that seem to indicate that a lot still has to be done in terms of trust and long-term commitment between buyer and supplier. For instance, as reported by many interviewees, the use of NDAs is becoming a norm in the industry. One could argue that this heavy reliance on NDAs is an indicator of a real absence of trust between parties. Moreover, it is observed from the interviews (#12) that not every party is willing to apply open book accounting with its partner. In fact the only 2 respondents (#10 and #11) who reported using open book accounting admitted doing so only with key customers who had sufficiently proven their trustworthiness. Therefore it seems also important for buyers to make more effort into showing their suppliers that they can be trusted.

It is obvious that when trust is absent, it becomes difficult for parties to commit during early involvement. This difficulty in long-term commitment between parties can also be explained by the uncertainty present in early stages of the project. For instance, at the moment that a contractor is aware of the project through 'route decision' and decide to bring a supplier on board, there are still a lot of uncertainties about the project. As such, it is often difficult for both parties to make a formal agreement on risks and rewards.

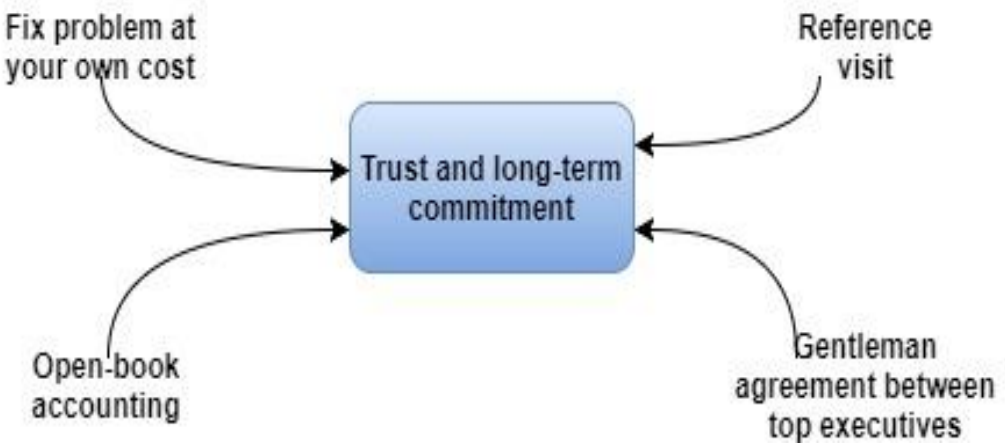

Figure 6. 3: reported practices to ensure trust and long-term commitment

6.2.4 Risks and reward sharing

Success in ESI often depends on risk and reward sharing between parties. Nevertheless, when approached on the question, most interviewees admitted not having formal risks and reward sharing formula during early involvement. In a sense, this can be considered as a big impeding factor to the good practice of ESI. Still, reason for this can be attributed to the lack of uncertainty surrounding initial phases of project as explained in the previous section. Mostly, risks transfer to suppliers depends on the nature of the contract between client and contractor. In this kind of setting, the supplier involved is often liable up to his fee (#10). However, what commonly occurs is that prior to writing the proposal, contractor and supplier can sometimes agree to share expenses for making the proposal at the condition that in case the project is won, that supplier will be selected. In that sense, a strong agreement is often required to enforce such arrangement, and risk distribution is often discussed with the supplier (#7).

6.2.5 Knowledge and information sharing

According to Ragatz et al. (2002), for a successful supplier involvement there must exist a constant flow of information between involved parties. In the Oil and Gas industry for example, Knowledge sharing occurs in the form of Intellectual Property (IP) right sharing between customer and supplier, as reported by respondent #10. In that sense, client and supplier engage in joint project development within which they share IP rights (#10). In the Dutch infrastructure sector however, Knowledge sharing between buyer and supplier is quite limited. For instance, at the exception of some few parties who will only share their key information provided the NDA has been signed (#7), there are still some resistances from parties to share confidential information or intellectual property rights (#2, #3, #4, #7, #8, #12). This resistance to knowledge and information sharing can be attributed to many reasons:

First of all, in the Dutch infrastructure sector, there is no strict differentiation between partners and competitors. In other words, ‘’a project partner of today, can become a competitor on the next project”. As such, maintaining a strategic position in the market can be very advantageous. Consequently, project participants are often concerned with sharing their key knowledge. This is confirmed by respondent #7 in these terms:

‘’don’t show them everything. Within projects you always have elements which are the real differentiation between you and the competitor. And my general practice is that if it's really confidential, don't tell it to anybody”.

And further supported by interviewee #6 with the following remark:

‘’in infra world, everybody talks to everybody. So if you have knowledge about a certain subject, and you share that with the supplier market in the infra world, then that knowledge will be common knowledge, and we don’t want to have specific knowledge becoming common knowledge”.

Another reason for not sharing knowledge and information depends on the type of agreements between parties. For instance as mentioned by respondent #13,

"If the arrangement is very informal then we find that idea sharing is very limited as there is no commitment from either side to be bound in a bid for the project".

Moreover, parties can sometimes use the knowledge and information they have as a bargaining chip in order to obtain what they want. This is pointed out by interviewee #9 who described a situation in which one party can propose to share its key knowledge at the condition of being part of the consortium.

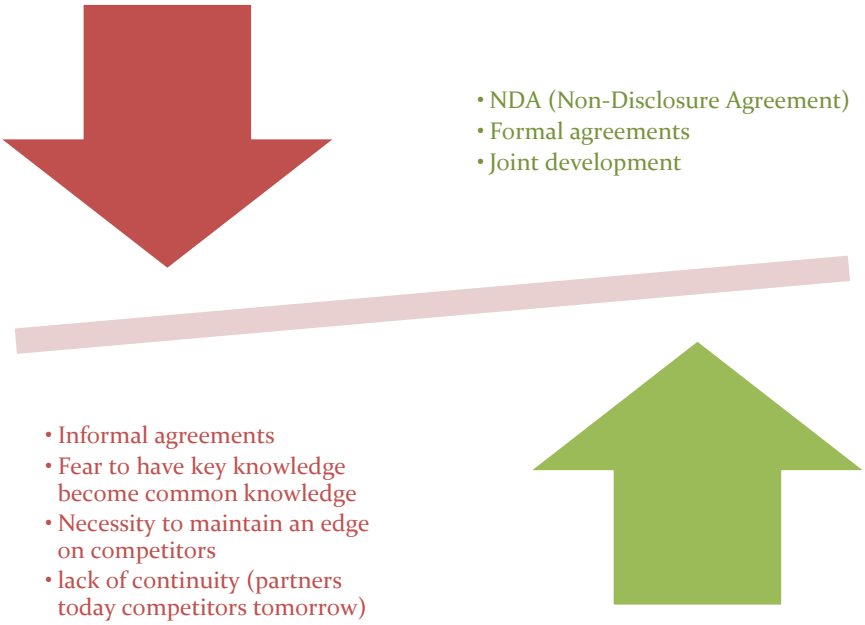

Figure 6. 4: Factors influencing knowledge and information sharing between buyer and supplier

6.3 Current barriers to early supplier involvement in the Dutch infrastructure sector

6.3.1 Issues related to parties' behaviour and attitude

Opportunistic behaviour from the supplier is often seen as a source of problems during ESI. Indeed as reported by interviewees #7 and #9, suppliers can sometimes take advantage of the situation to obtain what they want. For instance, at the proposal phase where contractors and supplier work together, information at the disposal of the contractor is very abstract, as such a "gentleman agreement" is often made between both parties based on those information. However, when the contract is awarded, suppliers can sometimes take advantage of the limited amount of time available to reject the terms from the previous agreement, thus exposing the contractor to renegotiate those terms or face the trouble of finding a new partner (#7).

Likewise, it is often difficult for a contractor to commit a key supplier when that supplier is solicited by many other contractors (#9). This finding somehow confirms the influence of other customers on the attitude of suppliers as suggested by MacDuffie and Helper (1997).

Furthermore, even when that supplier agrees to collaborate with the contractor in early involvement, there is still reluctance from his side to share all his knowledge and information with the contractor as stressed out by respondent #9 in these terms:

''normally with specialists issues, they are very reluctant to say a lot in early involvement stages, because they think "you are one of the contractors, I won't give you all my details, because I will keep my hands on my chest, and I wait till contractors will call me, and I wait as long as possible with the details of my solution".

This situation makes the collaboration very difficult between both parties. However, this reluctance in knowledge and information sharing can be attributed to the different reasons mentioned in section 6.2.5.

Moreover, respondent #8 points out the fact that most suppliers are still stuck in the traditional way of thinking and as such do not behave as it should be when involved early in projects. Interviewee #8 therefore believes that the difference in culture between organisations constitutes a big issue when involving suppliers early. As such, making sure that parties are 'on the same page' can be difficult to achieve. In this regard, interviewee #10 claims that difficulties often arise due to the absence of long-term understanding from different parties. This assertion is supported by respondent #13 who reported the difficulty to aligning on the end goals of both client and contractor as one of the main difficulties during early involvement. In this regard, respondent #13 suggests:

''approaching the client, interesting them in a solution, demonstrating the benefit of the solution to the client and then getting the client to specify this type of product or solution in the end infrastructure. In this case the contractor is bypassed at the early stage (as they are not inclined to be bound by early involvement solutions) and only become involved when the solution is demanded of them by the client.''

These findings somehow confirm the need for long-term alignment of all supply chain partners. Individual parties should not strive for their own interest, but instead try to work towards the same goal.

For respondent #11 on the other hand, the attitude of some contractors who sometimes hide key information to their supplier can bring lots of difficulties in the project and in the collaboration between parties. This situation is illustrated by the following quote:

''EPC's on the other hand, almost always hide information. For example if a project is delayed due to construction issues, they keep our milestones the same with the result that sometimes our deliverables need to be stored somewhere since the site is not yet ready for it.'' (Interviewee #11)

However, it can be argued that the attitude portrayed in this quote from respondent #11 is not representative of a whole contractor's company, but instead somehow indicates the behaviour of some individuals within the contractor's organisation who have no interest in collaborating with the supplier. In the literature, Wynstra et al. (2001) mentioned similar behaviour from employees of the buyer organisation who were afraid to lose their job as a result of the collaboration with the supplier. Thus those employees could erect barriers to the collaboration by setting unrealistic targets or

hiding key information. Therefore, it becomes important for the top management to step in and ensure commitment from their employees.

A similar source of difficulties during ESI can come within the contractor's organisation through its subsidiaries. Indeed, in infrastructure projects, contractors can sometimes bring their subsidiaries on-board as early involved suppliers. However, problems can occur when those subsidiaries do not comply to the agreement made with their mother company (#7). This often results in disputes between parties, thus further hindering the collaboration process.

Likewise, according to respondent #11 and #12, contractors are known to behave opportunistic by flowing all the risks down to the supplier during early involvement. Respondent #13 on the other hand reports the fact that contractor often *''wish to retain as much flexibility on price and solution till as late in the process as possible*''. Respondent #13 further stresses the negative attitude of contractors who prefer *''to fix prices very late in the process so that they can squeeze suppliers if they themselves have had to cut margins to win the work''*. This somehow suggests that contractors use suppliers as a buffer to get a grip on their own margin. One could believe this to be the immediate consequence of the initial price competition that occurs during tendering.

Additional source of difficulties of ESI can be found in the solution space allowed by the client. According to respondent #7, the boundaries put by client are sometimes tightened in such a way that it becomes more or less a price competition, which indirectly implies specific types of solution. As such the point of involving suppliers earlier loses all its sense.

6.3.2 Information-related issues

In ESI, information is very important in order to draw a strategy for involving suppliers. However, as reported by respondent #9, it is sometimes difficult for contractors to commit their suppliers due to the abstract level of available information at the pre-tender phase of a project. As previously mentioned, due to the European procurement law, public clients are often obliged to maintain a 'level playing field' (making sure that every party who is participating in a tender, has the same level of knowledge and information about the project) with project participants. This implies not giving away detailed information about the project to a specific party during pre-tender discussions. Consequently, this situation indirectly impacts the way early supplier involvement takes place. For instance, because contractors do not have all information on the project, it becomes difficult to have a formal agreement with their key suppliers in which all risks and reward would be discussed (#9). Respondent #12 slightly shares the same view and believes that that initial uncertainty makes it difficult for suppliers to know the end goal and reward for doing the project. Therefore it becomes difficult for those suppliers to fully commit to the project

Moreover, the quality of information also plays an important role in the timing of involvement. As acknowledged by respondent #6, given the amount of information available, it can be difficult to know at which point in time a supplier should be involved. As such, involving a supplier too early/late might be costly and might not yield the expected added value.

Finally as mentioned previously, parties do not always trust the guarantees offered by the NDA. As such, interviewee #12 believes this makes it difficult to assess with which party to share key information, combined to the fact that the agreement between parties is not always clear (#7).

6.3.3 Issues related to the nature of infrastructure projects

Almost all interviewees agreed on recognising the nature of the Dutch infrastructure sector as a source of difficulties in the ESI process. For respondents #2 and #6, the one-off nature of infrastructure projects makes it difficult to generate any kind of continuity between involved parties. In other words, given the uniqueness of every infrastructure project, parties involved in projects are almost never the same. Once a project is completed, parties often disband and look for other projects with new partners.

For respondent #10 in contrast, the difficulty resides on maintaining the right balance between the conservative nature of the infrastructure industry and the fast technology advance. That difficulty is explained by the following quote:

''The other challenge that we see is the fast moving technology. Nowadays technology is moving so fast that when a new operating system is being introduced, some things are not supported anymore, new features are brought to the market. This is somehow good for our industry, however, the most important for our industry is safety, reliability and productivity. People are not always waiting for the last gadget, because the industry itself is very conservative." (Interviewee #10)

The quote perfectly illustrates for instance the case with IT components relevant for infrastructure projects such as tunnel installations. In that market, the technology advance is quite fast. Let's take the example of software suppliers for tunnel installation. There it is obvious that the rate of technology advance is higher in comparison to concrete and bolts. As such, a solution provided today might become outdated the next month or year. It is therefore important that parties such as client and contractors understand that situation and act accordingly with those types of suppliers.

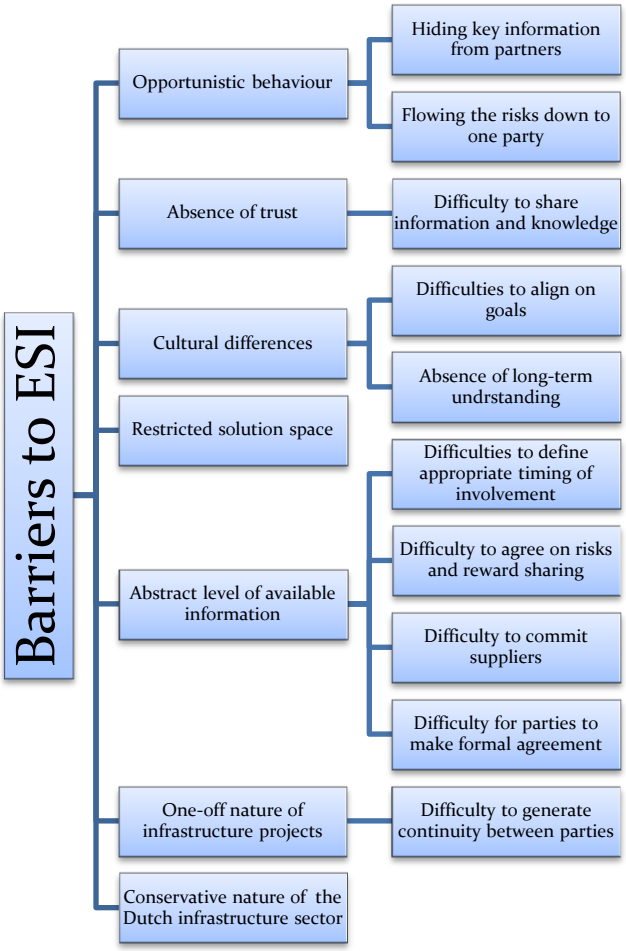

Figure 6. 5: common barriers to ESI in Dutch infrastructure projects

6.4 Synthesis

The findings of this study highlighted some lessons that the Dutch infrastructure sector in general should consider in order to further stimulate early supplier involvement:

- The client should increase design freedom and boundaries and avoid as much as possible to put price upfront as a criteria during tendering. For instance, the client can give freedom to contractors and their suppliers to come up with design ideas and add price themselves to it. Then the client could award the project based on the best idea and price if necessary, which in itself would not conflict with the European law. Doing so would stimulate creativity and allow both contractors and suppliers to come up with really innovative ideas.

- Emphasis should be put on addressing the right issues and providing only relevant information during pre-tender phase. The reason is because information gathered at this stage is often used to determine which supplier to involve and how early he should be involved (#6).

- In order to stimulate long-term commitment, the client should set criteria that oblige project teams that have been working together for the proposal to continue their collaboration in case the project is awarded. This will indirectly enforce the ''gentleman agreement'' made between contractors and suppliers, and will also indirectly force parties to really work out their differences before entering a ''gentleman agreement''

- During pre-tender discussions, the client should address topics that somehow force contractors to consider whether they have the expertise or whether they should involve the right expertise to solve the problem. As such, the client would be raising awareness of using early supplier involvement without explicitly implying it. Currently this approach is being followed by Rijkswaterstaat (#1), nevertheless more efforts should be put in that direction.

- The top management of both buyers and suppliers organisation should be aware of the importance and added value of ESI, and therefore commit their staff to working with the other party.

- Parties should understand the importance of the long-term aspect of ESI, and therefore avoid striving for short-term profits

- The client should standardise more on building blocks related to fast moving technology such as ICT components of tunnel project. Currently Rijkswaterstaat through its branch CIV is developing on that direction; however the process should only target a restricted number of suppliers.

- Efforts should be put by all parties in finding a working formula for risks and reward sharing, as collaboration appears to be effective when both parties feel rewarded for their efforts.

- Contractors should be able to strategically classify their suppliers in terms of importance, and therefore know how to act depending on which supplier. Contractors should be aware of the importance of giving the right incentive to key early involved suppliers, and therefore avoid as much as possible squeezing on their margins. It is understandable for contractors to squeeze suppliers of commodity or standard goods, but if there are only two suppliers that can provide one key technology, as a contractor it will not be good to squeeze them. In this case partnering with them will be more appropriate.

- Both client and contractor should clearly communicate what the goal and risks are during the early involvement situation. Also, they should both be clear upfront what should happen with IP rights (#12). This will enable suppliers to know in advance what to expect in terms of risks and reward, and therefore facilitate their commitment.

- The client should be more in control, particularly for project where ESI would be needed. In that case, the client should design the right framework that kind of prevents the contractor from squeezing supplier's margin.

- Suppliers should take more initiative in showing their commitment and trustworthiness to their partner. For instance, having open book accounting can be a good starting point.

However, one should not ignore the risk that such cost transparency can be used by contractors to increase their power over suppliers or squeeze suppliers' profit margin even further.

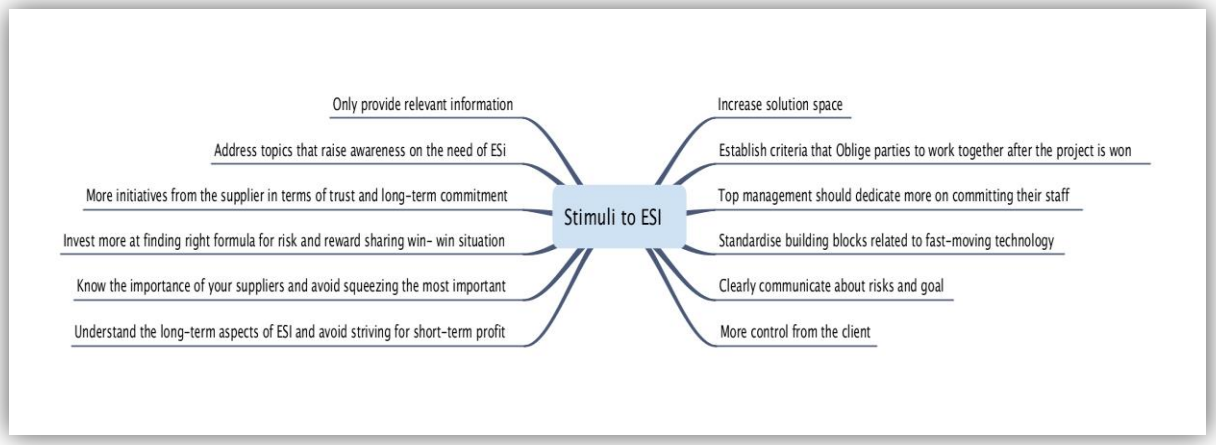

Figure 6. 6: possible stimuli to ESI in Dutch infrastructure projects

7 Discussion

In this chapter the research findings are further discussed, then insights are given on the limitation of this research, followed by recommendation for future study.

7.1 Discussion of the findings

The findings of this research have shown some positive signs of ESI practices within the Dutch infrastructure sector. Responses yielded regarding familiarity with ESI, timing and extent of supplier involvement, have indicated that the practice of early supplier involvement is well implanted in the Dutch infrastructure sector, although not recognised under the label ''ESI''. An interesting observation made from the interviews is the fact that all respondents denied the influence or pressure from the client in the decision to involve suppliers early. This somehow indicates the degree of maturity of Dutch contractors who acknowledge their limits and recognise the importance of ESI in making better chances of winning projects.

Moreover, information retrieved regarding the timing of involvement showed some consistency with previous literatures on ESI. In other words, the earlier a supplier is involved, the more important he is for the solution. A link was also found between the timing of involvement and project complexity and required degree of innovation. In terms of degree of responsibility given to suppliers, it was interesting to observe that the Dutch infrastructure sector makes use of all categories of supplier involvement as described by Handfield et al. (1999). This somehow indicates how important suppliers' organisations have become in the Dutch infrastructure sector. In this context, the most remarkable observation is perhaps the willingness of suppliers to take even more responsibilities and risks provided they are proportionally rewarded for doing so. In contrast, the attitude of suppliers who would pull out from an agreement because they could no longer accept the risks, somehow conflicts with the previous finding. One can argue this to be a good indicator that suppliers are not rewarded sufficiently to take on more risks and responsibilities.

Regarding the increasing importance of suppliers in projects, interviewees have reported standardisation of project components such as tunnel phone installations and the intention from the client Rijkswaterstaat to standardise even more ICT components. In contrast, standardisation on non IT-related projects components was not mentioned by any respondent. In the previous chapter, different reasons have been given to justify that situation. However, one could argue that such trend in standardisation indicates that the client has understood the importance of creating some continuity regarding components that could be subjected to fast technology change. Therefore is putting more effort to kind of make it uniform to the market. In other word, the importance of having one supplier responsible for an ICT component for all tunnel projects for example in order to make project coordination less complicated

In terms of benefits and limitations, respondents showed quite some consistencies with literature on ESI benefits and drawbacks. The only thing that somehow contrasted with the literature was the fact of not recognising the fear of knowledge leak to competitor as a limitation of ESI. Perhaps, this can be explained by the nature of the Dutch infrastructure sector itself. In fact, in the infrastructure world, parties have more or less been in relation with each other as either competitors or partners. As such, for one party to leak key knowledge to another would basically mean getting out of

business, as he no longer would be trustworthy in the industry. That can somehow explain why interviewees did not consider knowledge leakage as a major drawback of ESI within the Dutch infrastructure world. However, it does not mean that parties are not careful regarding the key knowledge they possess. In fact, it has been observed that despite NDAs being used, there were still reluctances from parties to share their knowledge with their partners. One can tend to believe this attitude to be a consequence of the lack of true guarantees offered by the NDA, as confirmed through concerns shown by some interviewees regarding NDAs.

In terms of buyer-supplier collaboration, some encouraging elements have been observed from the interviews. For instance, it was interesting to notice the effort put by different parties in selecting the right expertise and assessing their capabilities prior to engaging in early involvement. It was also satisfying to recognise the use of colocation between buyer and suppliers' project team during early involvement. However, some other elements tend to show that there is still a long way to go in order to achieve effective buyer-supplier collaboration within this sector. One could argue that, achieving effective buyer-supplier collaboration during early involvement will require putting some efforts in overcoming the different barriers identified in this study and emphasising more on ways to further stimulate the process.

In the result chapter, different barriers to ESI have been identified as well as possible ways to overcome those. Here it is interesting to mention that those findings showed both some similarities and differences with some of the ESI barriers retrieved in literature. This somehow confirms the reason why ESI practice is often reported to differ per company and per industry (Dowlatshahi, 1998).

7.2 Limitations

The study performed in this graduation work only focused on a very restricted sample of participants. As such, the findings cannot claim to be representative of ESI practices in the whole Dutch infrastructure sector.

Additional limitation of this research can be the decision to opt for an interview-based research instead of a case study. This was because of the difficulty to find a completed project where ESI had been implemented. In general, data obtained from interviews do not represents hard facts, but instead are representative of interviewees' opinion. Thus, using interviews as a method of research kind of compromise the reliability of the results. In the present case, the choice was made to check the consistency of the research findings with the literature.

Moreover, the research did not focus in too much detail on different ESI aspects addressed in this paper. As such, no strict conclusion can be taken regarding whether or not ESI is well implemented in the Dutch infrastructure industry

7.3 Further research

The findings retrieved from this research have shown where the Dutch infrastructure stands in terms of ESI. For instance, timing of involvement has been identified as a major difficulty in ESI. However, research on the field of ESI in the Dutch construction industry is almost inexistent. It is therefore suggested to have more specific researches regarding ESI aspects such as timing and extent of involvement. In this regard, it could be ideal to look deeper into those aspects and perhaps come up with some kind of conceptual model or framework that could guide Dutch practitioners when engaged in an ESI process.

Another idea could be to develop a measurement tool that could serve to really evaluate how good the Dutch infrastructure sector is doing in terms of early supplier involvement. The idea here would be to conduct such research on a far bigger sample than the one represented in this study.

Furthermore, it could be interesting to investigate the practice of ESI per project type based on forms of collaboration such as Design and Construct (D&C), Design Build Finance and Maintain (DBFM) and many other types. In this regard, perhaps additional researches should be done to identify which forms of collaboration are more or less suitable for the practice of early supplier involvement.

Finally, in this study the aspect of managing multiple suppliers during ESI has only been briefly addressed in section 3.4 (figure 3.4). Therefore, it is suggested to dedicate a study on how organisations should manage the simultaneous involvement of multiple suppliers in projects.

Part IV: Conclusion and recommendations

8 Conclusion

This research was conducted with the aim of investigating the current state-of-affairs of the Dutch infrastructure sector regarding the implementation of early supplier involvement, identifying barriers and stimuli to ESI within the sector and deriving some recommendations for achieving success with ESI. Meeting those objectives required bringing some element of answers to the main research question formulated as follow:

> *"What is the current status of Dutch infrastructure projects in terms of early supplier involvement: what barriers should be overcome and what areas should be stimulated in order to achieve success in early supplier involvement?"*

In order to address the main research question, it was necessary to first answer the following five sub research questions.

SQ1: What is early supplier involvement and how is it applied in other industries?

Early supplier involvement or ESI is a concept that has been in practice for over half a century now in New Product Development (NPD) (Wynstra et al., 2001). However, it was until the year 1991 that researchers Clark and Fujimoto highlighted the importance of ESI by comparing performance gaps between Japanese and western car manufacturing companies.

In literature the definition of ESI varies per industry or sector of activity. For instance, Dowlatshahi (1997) defines ESI as a mechanism for involving preferred suppliers in the early phases of product design and development. For Dobler and Burt (1996) ESI is a means of integrating suppliers' capabilities in the buying firm's supply chain system and operation. In this paper, we opted to define ESI in the Dutch infrastructure context as a form of buyer-supplier collaboration that takes place prior to the construction, maintenance and operation phase. The main idea with ESI is that buyers (client/contractor) do not know everything, and as such, should integrate suppliers with key competencies early in the process in order to 'better' execute the project.

The level of supplier responsibility in ESI may range from simple consultation with suppliers on design ideas to making suppliers fully responsible for the design of components or systems they will supply. In this sense, references can often be made to "white box", "grey box" and "black box" suppliers depending on their degree of responsibility during early involvement.

Similar to any other concept, ESI is known for its benefits but also its limitations. In terms of benefits, ESI is important in reducing the cost for development, reducing development lead-time and supply risks, reducing production cost, improving product quality, facilitating access to key technology, managing outcome uncertainties (Wynstra et al., 2001; Ragatz et al., 2002; Wasti and Liker, 1997). However, in terms of limitations, ESI is believed to be time and resource consuming. Moreover, ESI can lead to a loss of proprietary knowledge and internal key-competencies. Also companies implementing ESI are exposed to the risk of technology spread to competitors, risks of "lock-in" to supplier's technology, and ESI is known to increase complexity due to buyer-supplier

interface. ESI often implies the establishment of cross-functional project teams composed of buyers and suppliers members.

Reasons for adopting ESI can vary per industry and even per companies within the same industry. This is perhaps because before engaging in an ESI process, most companies from other industries take into account factors such as the nature of the project, the type of suppliers, the degree of technology uncertainty and the degree of innovation. Therefore, regarding the question *''how is ESI implemented in other industries?",* it is perhaps cautious to conclude that there is not a single way of implementing ESI that is particular to a specific industry, as far as this research is concerned. Instead, all ESI efforts so far have been developed to meet the specific needs of particular firms, as there are currently no available standard, framework or guidelines for ESI implementation (Dowlatshahi, 1998).

SQ2: What lessons could be learned from other industries in terms of early supplier involvement?

In terms of lessons learned from ESI in other industries, several aspects have been identified as key prerequisite in order to achieve success with ESI:

Trust

Trust represents one of the most important aspects of buyer-supplier relationship (Morgan and Hunt, 1994). Trust allows partner to no longer worry about opportunistic behaviour and leakage of key knowledge. As such, trust is also recognised to facilitate knowledge exchange in early buyer-supplier relationship. However, parties should be aware that trust is a process that takes time to be built, but can be destroyed in an instant through opportunistic behaviour (Johnsen, 2009)

Communication

According to Brown and Eisenhardt (1995), communication can facilitate the comprehension of information and enhance overall performance. Among all means of communication, face-to-face communication is recognised as the most effective way of communicating in buyer-supplier relationship. In this regard, having a temporary project location (colocation) where buyer's and supplier's team could work together is acknowledged important as it facilitates intensive communication between partners. Additionally, communication through email is also advised as a good way to convey information while face-to-face communication best serves in case of mediation.

Top management's support

Support from top management is crucial for ESI success, as it facilitates commitment and enhances collaboration and information sharing between staff. In other words, when there is commitment at the top of an organisation, the bottom usually follows. Also, top management commitment between buyer and supplier's organisation can be beneficial in aligning both organisation towards the same goal.

Knowledge and information exchange

For success during ESI, there must exist a constant flow of information between parties. Sharing the information and technology at early stages of the project can make the difference between success and failure, particularly in case of technological uncertainty. Besides, sharing information and knowledge improve trust between parties

Long-term commitment

Long-term commitment is a good way to build trust between parties. Ways to create commitment between parties could be through contractual agreement or by bringing support to the other party in times of difficulties.

Formalised risks and reward sharing/ win-win situation

When parties are willing to share risks, it often helps developing trust and long-term commitment. For ESI to be successful, a feeling of win-win situation between parties is very important. This implies that suppliers should be able to measure their increased responsibilities in terms of profit. Thus each partner should be rewarded proportionally to their efforts.

Customer's ability to manage supplier involvement

Success in ESI depends on the buyer's ability to determine when and which supplier to involve. Giving certain responsibilities to the wrong supplier can result in undesired outcome such as the buyer spending resource and time to manage that supplier.

Supplier's capability

A supplier that possesses the right capability can often assist the buyer in responding to various challenges from the marketplace. Skills from technically capable suppliers can often help to speed up the product development process.

In regard of the different barriers identified in this study, we therefore advocate trust, long-term commitment, formalised risks and reward sharing, knowledge and information exchange as the most important aspects that organisation should focus on when engaging in ESI in the Dutch infrastructure sector.

SQ3: What is the extent of suppliers' involvement in Dutch infrastructure projects?

Through the different responses retrieved from the interviews, it has been observed that supplier involvement in Dutch infrastructure projects is consistent with all four categories of supplier involvement presented in the model of Handfield et al. (1999).

Basically, according to interviewees, suppliers can be involved in infrastructure projects for delivering goods (''no involvement''), giving quotations for materials or advising in writing project specifications (''white box''). For the next level of involvement, supplier are reported to take part to joint product development with the buyer's organisation (''grey box''). Finally the highest level of responsibility given to suppliers is the ''black box'' in which suppliers are given full responsibility on the design of certain parts of the projects. In such situation, the client/contractor pushes the functional specification to the supplier without applying any change on it, then the supplier makes the design and returns it to be checked.

In a nutshell, if one considers the different barriers to ESI identified in chapter 6 of this report, it can be tempting to say that Dutch practitioners do not practice ESI in a structured professional approach. On the other hand, aspects discussed among which standardisation and the implementation (already) of all four categories of supplier involvement tend to show how far the Dutch infrastructure sector has got in terms of ESI practice. In a sense, this somehow indicates that

the Dutch infrastructure sector is on the right track regarding the practice of ESI, nevertheless there is still a long way to go for the sector, as illustrated by the different barriers identified in this study

SQ4: What are the barriers and stimuli to successful early supplier involvement in Dutch infrastructure projects?

Based on interview findings, barriers to ESI within the Dutch infrastructure sector can be attributed to:

- Opportunistic behaviour
- Cultural differences
- Absence of trust
- Restricted solution space
- Abstract level of information provided at pre-tender phases
- Conservative nature of the Dutch infrastructure sector
- One-off nature of infrastructure projects

Potential solutions to stimulate ESI are as follow:

- Promote understanding of long-term aspect of ESI and avoid striving for short-term profits (hit and run mentality)
- Only provide relevant information and increase solution space
- Discuss topics that indirectly raise awareness on the need of ESI
- Invest more in finding risks and reward sharing formula
- Buyers should know the importance of their supplier and avoid squeezing the important ones
- More initiatives from suppliers in terms of trust and long-term commitment
- Establish criteria that obliges parties to work together after the project is won
- Top management should dedicate more effort in committing their staffs
- Standardise building blocks related to fast moving technology
- Have clear communication about risks and goals
- More control from the client

SQ5: Which key project-aspects can justify involving suppliers earlier?

The findings from this research suggest different project aspects for which ESI can yield the most added values. First of all, ESI is suitable for projects where there is sufficient space for development. This allows both buyer and suppliers to have some freedom in providing their solution, which can often lead to innovation. Furthermore, ESI can be relevant for projects requiring a specific and rare

technology. In parallel, ESI can also be suitable for projects requiring specific and complex types of solutions. Moreover, for projects where lead-time is a key criterion, ESI can be of great value. For instance, there can be a project that must be designed and executed in a very short time frame. In this case, bringing a key supplier as early as possible can help the buyer's organisation to address initial challenges of the project within a shorter timeframe.

With all sub research questions addressed, the main research question can now be answered:

MRQ: *"What is the current status of Dutch infrastructure projects in terms of early supplier involvement: what barriers should be overcome and what areas should be stimulated in order to achieve success in early supplier involvement?"*

Although the research conducted cannot be representative of the whole industry, it is encouraging to realise that the Dutch infrastructure sector is making good use of the capabilities that suppliers can bring early on in projects. This is illustrated by the awareness of client and contractors regarding the importance of involving key suppliers early in projects. Perhaps the best illustration of this awareness is the strategic decision taken by client such as Rijkswaterstaat in standardising more ICT project components in the future.

In addition, most data gathered from interviews showed quite some consistency with ESI practices as explained in literatures. For instance, it was satisfying to realise that currently the Dutch infrastructure sector has achieved all four categories of supplier responsibilities as described by the model of Handfield et al. (1999). This somehow indicates how far the sector has come in terms of making use of suppliers' knowledge in projects.

However, there is still a long way to go for the industry, particularly in terms of buyer-supplier collaboration during early involvement. Aspects related to parties' attitude and behaviour, information and knowledge exchange as well as the nature of infrastructure sector are identified as major barriers to ESI success within the industry. It is believed that overcoming those barriers would require putting some more effort into improving aspects that are known to be already stimulating ESI, such as standardisation and indirectly raising awareness on ESI during pre-tender discussions; but also working out differences in culture, communication, behaviour and attitudes between all parties.

9 Recommendations

9.1 General recommendations

Parties should clearly communicate upfront what the objectives and risks are for engaging in a project during early involvement. Also, they should clearly give their intentions and expectations early on regarding IP rights and sharing of sensitive information. It is believed that doing so could give sufficient time for parties to assess whether or not their goals are aligned with those of their partners and know whether it is wise to collaborate or not. Moreover, both buyer and supplier should dedicate their effort in finding the right formula for sharing risks and rewards. In addition, parties should also understand the long-term aspect of ESI, and avoid looking for short-term profits ("hit and run mentality"). Finally, parties must understand the importance of creating value together through collaboration. Therefore, there must exist a culture of collaboration that somehow breaks down internal barriers between buyer and suppliers' firms. In this regard, the top management of buyer and suppliers' organisation should dedicate more resources in encouraging collaboration from their respective staffs during early involvement, as suggested by Ragatz et al. (1997) in section 3.8.3

9.2 Recommendations for clients

Give more freedom on design and price

The client should put more effort into stimulating innovation in project. One way of doing that could be by increasing design boundaries and freedom. Moreover, for project requiring specific types of knowledge, the client should allow competing parties to come up with solution and give them the possibility to add their price on those solutions. It is believed this freedom on design and price would enhance creativity and innovation, thus giving all its sense to the use of ESI.

Provide the right information

During pre-tender discussion, the client should double efforts in identifying and providing the most relevant information to the participants. Doing so will enable both contractors and suppliers to really know what to expect, and therefore have a better appreciation of risks and rewards, which in turn could enable them to enter stronger agreements.

Stimulate long-term commitment

Long-term commitment is a key ingredient for success in ESI, although it is not always easy to achieve it. Perhaps, the client can indirectly influence long-term commitment by means of requirements. For instance, the client could set a requirement that obliges the same project team that worked on the proposal to be the same that continues the work when the project is awarded. One could argue that doing so could help prevent parties from leaving agreement when the project is awarded and would somehow promote long-term commitment.

Indirectly raise awareness on the necessity of ESI

By addressing specific topic during pre-tender discussions, the client can indirectly imply the necessity to use knowledge from suppliers without imposing it as a requirement. As suggested by the study, clients such as Rijkswaterstaat are already doing that. Nevertheless, it is recommended to put some more efforts in that direction.

Exert more control

The client should have more control on project aspects that are subject to high rate of technological change. This is for instance the case with ICT components of infrastructure projects, as previously suggested in section 6.1.5. As such, it is believed that through standardisation on those key aspects, the client could ensure some kind of uniformity and reduce complexity in project coordination during early involvement.

9.3 Recommendations for Contractors

Understand your supply base

Contractors should have a good understanding of the importance of each of their suppliers. Therefore, they should classify those suppliers and put more efforts into developing long lasting relationship with the key ones. This can be achieved for example by investing on that supplier's production machines, or by some other forms of financial assistance when needed as suggested by Eisto et al. (2010) in section 3.8.5.

Provide the right incentive to your key suppliers

The study has highlighted the willingness of suppliers to take on more risks and responsibilities in project, provided that the reward follows the same pattern. In a sense, this somehow shows the importance of creating a win-win situation when working with key suppliers. It is therefore recommended to contractors to provide sufficient incentives to keep their key suppliers committed during early involvement. This implies recognising that suppliers also need certain margins to survive and be able to provide the solution they agreed to. Therefore, contractors should try as much as possible to reward their suppliers proportionally to their contribution and avoid squeezing on their margins, as suggested by Kulmala et al. (2002) in section 3.8.6 of this report.

Do not target small margins

As suggested by this study, ESI is a process that requires lots of efforts from organisation taking part in it. For this reason, contractors in particular should avoid bidding for projects where they know will require involving their suppliers early but would yield small profit. The reason is because the risk would then be too big that the contractor ends-up squeezing on that supplier, which in turn could impact the capacity/will of that supplier to deliver what he promised, resulting in lots of troubles.

9.4 Recommendation for Suppliers

Know your customers

For suppliers it is important to know their customers base and classify those based on competencies and long-term working relationship. In this regard, suppliers should be able to identify the most relevant customers, and make some extra efforts to show their trustworthiness and commitment to those. For instance, having open book accounting could be a good starting point for suppliers to demonstrate good intentions.

Behave as a partner

In section 6.3.2, it has been shown that the abstract level of available information during pre-tender phase of projects makes it difficult for contractors to fully appreciate risks and rewards, and secure strong agreements with suppliers. It is therefore suggested to key early involved suppliers to have an understanding of the struggle that contractors face in early project phases and behave as partners. This implies sticking as much as possible to the agreement made with contractors, since behaving otherwise could have an influence on their reputation and chances for future projects.

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