The influence of lean planning on trust and time performance in construction projects

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The influence of lean planning on trust and time performance in construction projects

By

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Preface

This thesis is the concluding part of the "Construction Management and Engineering" master degree at Delft University of Technology I started in September 2014. This graduation research project was conducted in Bouygues Batiment in Paris focusing on the implementation of the Lean Construction principles in building projects. The reflection on this thesis started during my exchange program in Harbin, China where the Chinese philosophers Confucius and Lao Tzu - quoted below - had inspired the research project. This thesis was only possible with the support of some people I would like to acknowledge.

I would like to thank the Thesis Committee members - Hans Wamelink, Ruben Vrijhoef and Martijn Leijten - for their valuable academic guidance and constructive remarks on the research topic during the seven months. Despite the distance, they made the research process going smoothly through regular Skype meetings. Our meetings were a source of motivation to improve my works and I really appreciated to share my work progress and exchange with them.

A special thank for my external supervisor, François Briand, for his warm welcome in the company and his advices throughout the research process. He gave me the opportunity to develop new skills during the six months I spent in Bouygues Batiment Ile-de-France. I really appreciated to visit building sites and to meet the project's actors. I also would like to thank all the colleagues I met on construction site or in the head office to allow me some time to share their knowledge with me. I learnt a lot on the construction management process in the company and it helps me a lot to build my professional project.

Many thanks to the interviewees for spending time to contribute to my research project. Their inputs were essential for my thesis.

Paris, June 2016
Margot Piet

"A man who does not plan long ahead will find trouble at his door"

Confucius

"He who does not trust enough, will not be trusted"

LaoTzu

Executive summary

Introduction

Bouygues Batiment, a French construction company, had identified room for improvements on their building sites regarding the trade works planning. They have decided to implement lean planning tools to promote collaboration with and among the subcontractors. Lean construction theory was developed since the early 1990's based on the lean management principles from Toyota production. Ballard had developed specific lean tool to planning aspects and project time performance: the Last planner system (Ballard, 1997; Ballard et al, 2002).

Research framework

This thesis aims at assessing the influence of lean planning tools on the project time performance regarding the trust relationships between the project's actors. The research project is articulated around the following research question.

> *To what extent does the implementation of Lean planning tools influence time performance of building projects through the improvement of trust relationships?*

The research scope is focused on two kinds of relationships among the project's actors: (1) the relationship between the contractor and the subcontractors and (2) the relationship among the subcontractors. To structure the report and provide an answer to the research question, five research hypotheses had been drawn (shown on Figure 0-1).

> **Hypothesis 1**: The implementation of Lean planning tools leads to a greater level of trust between the contractor and the sub-contractors.
> **Hypothesis 2**: The implementation of Lean planning tools leads to a greater level of trust among sub-contractors.
> **Hypothesis 3**: Greater level of trust leads a greater project performance concerning planning.
> **Hypothesis 4:** The implementation of Lean planning tools leads directly to greater project's performance concerning planning.
> **Hypothesis 5:** The implementation of Lean planning tools leads to greater project's performance concerning planning through other factors than trust aspects.

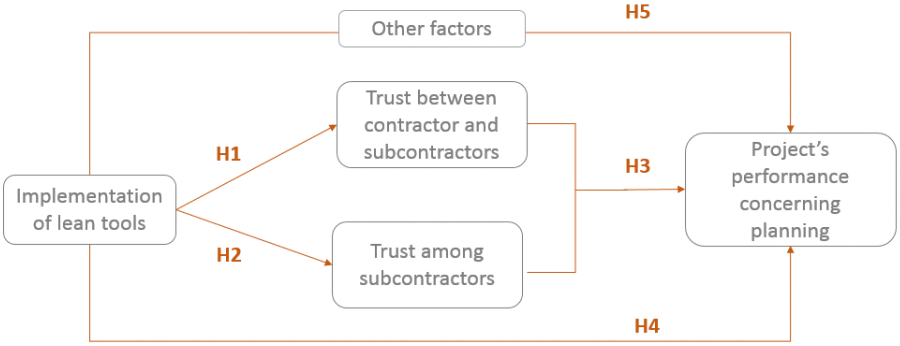

Figure 0-1 Overview of the five hypotheses

Methodology

The research strategy is based on seven case studies: four projects with a lean approach and three projects in which the lean planning approach was not implemented. Those projects are quite similar: housing projects, located in Paris area, studied during the trade works phase, with the same contractual, technical and working procedure, etc.

The research protocol is founded on questionnaire statements divided into four parts: (1) degree of lean implementation to ensure the identification of the two groups of projects; (2) trust aspect – related to the first two hypotheses; (3) the project time performance – associated to the last three hypotheses. Regarding the assessment of the trust aspect, three trust models had been selected from the literature: (1) the cognition-based trust; (2) the affect-based trust and (3) the system-based trust. Two types of questionnaire are drawn depending on the role of the interviewees in the project: contractor or subcontractor. The questionnaire statements are scored by the interviewees on a five-item scale based on their degree of agreement with the statements. The interviewees had the opportunity to provide remarks and advice on improvements besides their scores.

Analysis

The analysis process is decomposed into the two main steps: (1) the preparation step including the identification of the two groups among the seven case studies and the exclusion of other routes between the lean tools and project time performance; (2) the identification of the lean tools implementation influence through the comparison of the two samples regarding the trust aspect and the project time performance. The process is shown on Figure 0-2.

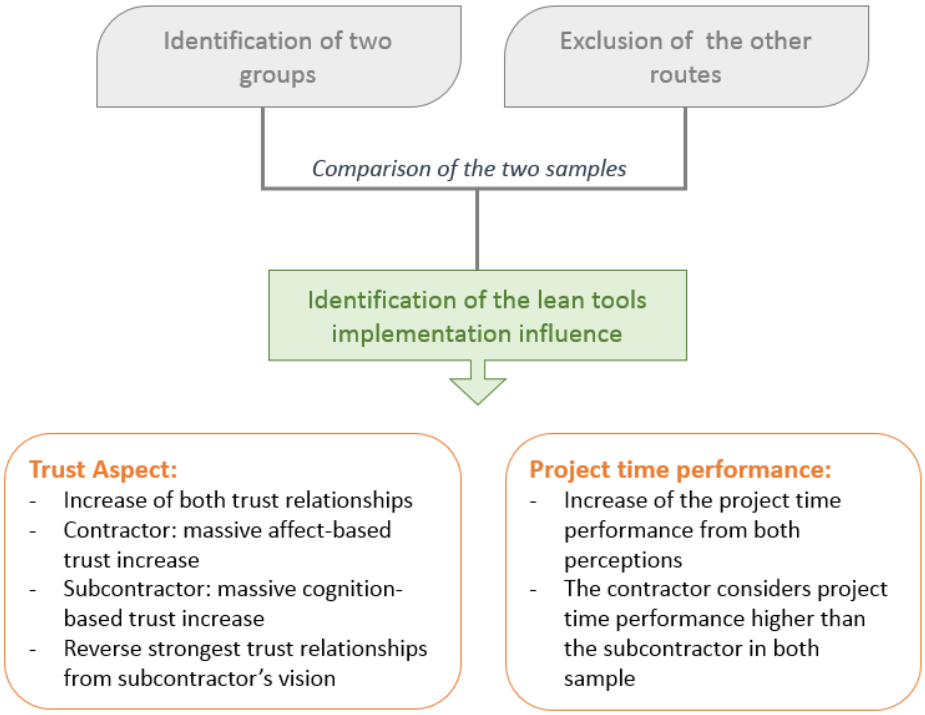

Figure 0-2 Analysis Process

Conclusion and Recommendations

The two kinds of trust relationship increased with the implementation of lean planning tools. However, the trust models were differently impacted: the affect-based trust had the major growth concerning the relationship between the contractor and the subcontractors and the cognition-based trust was the most impacted trust model concerning the trust aspect among the subcontractors. It is noticeable that the subcontractors shifted their highest trust relationship from the contractor to the other subcontractors. Thus, the implementation of lean tools regarding planning promotes predominantly the trust relationships among the subcontractors concerning the cognition-based trust (i.e. on competency and information flows) and to a lesser extent the trust relationship between the contractor and the subcontractors regarding the affect-based trust (i.e. on the thoughtfulness and the relational investment).

The time performance of projects had also increased with the implementation of lean tools regarding planning from both perceptions. The contractor scored it higher than the subcontractors: this is probably related to the "safety" margin generated by the contractor.

It is noticeable that the direct path between the implementation of lean tools and the project time performance is quite low even in the sample in which the lean approach had been implemented. This phenomenon highlights the substantial impact of trust aspect on the project time performance. In other words, alternative tools could be developed to build trust among the project's actors aiming at increasing the project time performance. Further research can also be focused on the assessment of other factors such as the influence of subcontractor's designation procedure on the approach. Other recommendations are given to the construction company regarding further development of the lean approach on planning aspects such as the development of logistic aspect, simplification of the lean tool, wider involvement of project's actors into the approach.

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Introduction

This section introduces the global thesis research project. First the general context of the construction company, Bouygues Construction, will be presented within the economic climate of the French construction industry. The second part of this chapter describes the structure of the report.

General context

The Bouygues Construction is a worldwide group presents in about eighty countries with more than fifty three thousand employees working on five continents. It had been ranked seventh in the ENR ranking of international contractor in 2015 based on the shares of sale on international markets (ENR, 2015). The group presents its five major assets and strengths as: (1) differentiation through innovation: from technical innovation such as BIM to commercial innovation; (2) strong international presence: generating half of its sales on international markets; (3) long experience of managing complex projects; (4) capacity to adapt in changing market and (5) a policy of controlling operating and financial risk associated to a robust financial performance (Bouygues Construction, 2015).

They have four main core businesses: (1) building; (2) energy and services; (3) civil works; and (4) the concessions. The total sale rose by 6% to €11.7 billion in 2014 and the order book stands at €18.1 billion. As shown on the Figure 0-3, the main activity concerns the buildings and the more dynamic area for the group is Paris and its suburbs (BouyguesConstruction, 2014a).

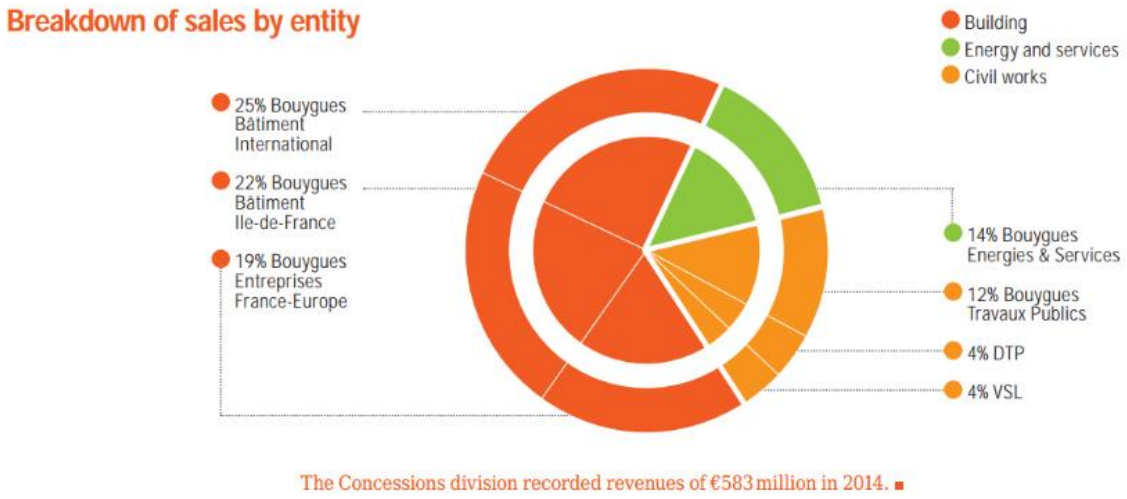

Figure 0-3 Breakdown of sales by entity in 2014 (Bouygues Construction, 2014)

The Bouygues construction group generated 51% of its sales in France in 2014. Thus, the French construction market is essential for the company. Bouygues Construction (excluding Bouygues energy and services) had been ranked in the top three of construction companies in France by *Le Moniteur*: ahead of Eiffage Construction but behind Vinci Construction.

Regarding the economic climate, the French construction industry had been seriously impacted by the economic crisis in 2008 as shown on the Figure 0-4. Recently, the construction activities start slightly to increase again but production capacity is still underused (INSEE, 2016). Subsequently, the competition between construction companies is still tensed and the resource optimisation becomes central challenge to continue their activities.

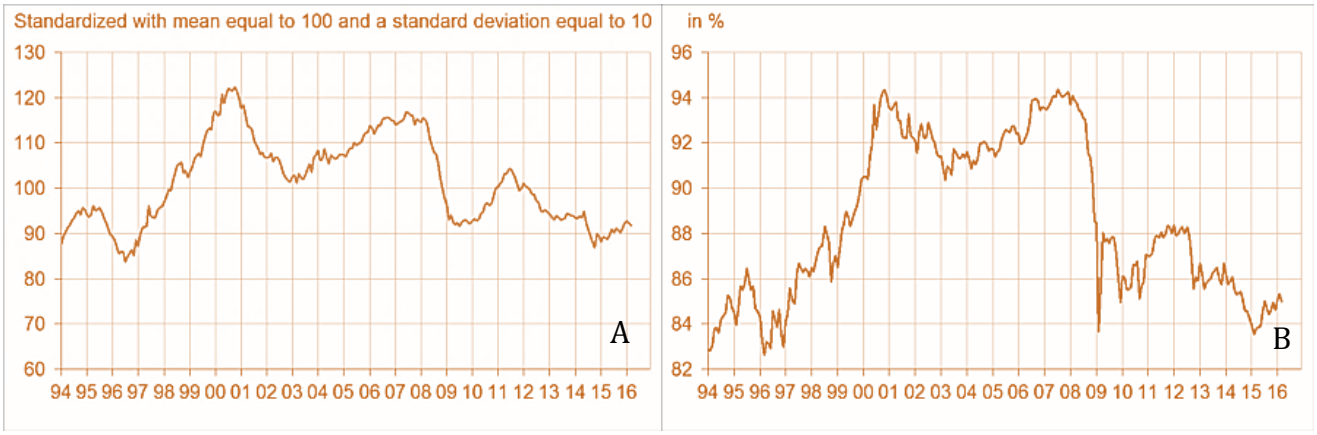

Figure 0-4 Economic situation of the French Construction industry. A- Business unit composite indicator; B- Production capacity utilization rate
Source: INSEE, French business survey in the building industry

*"During the construction, Bouygues Construction practices an **innovative collaborative approach** and leads a permanent process of dialogue with all its **stakeholders**."*
Bouygues Construction, 2014

The strategy of Bouygues construction is oriented towards two aspects: (1) involvement of the stakeholders into construction projects and (2) the sustainability of the construction. Indeed, as a contractor, Bouygues construction perceived the difficulties in the communication with different stakeholder and in particular subcontractor. They want to improve problem solving process trough collaboration among the project's actors to ensure the planning (Bouygues construction, 2014).

The economic climate and the company's strategy go in the same direction putting pressure on the planning and the financial margins to be more competitive. Lean management has reduced waste and has optimized the production in the automotive and manufacturing industry in the past century. Thus Lean construction can be considered as a tool to meet client's requirements with the project time performance by promoting collaboration. The collaboration is intrinsically linked to the trust aspect among the project's actors. This thesis will assess the influence of the implementation of lean tools on the project time performance through the trust aspect.

Structure of the thesis

The thesis is composed of three parts shown on the Figure 0-5: the first part describes the research framework, the second part deals with the analysis of the research project and the last part presents the conclusion and recommendations of the thesis.

The research framework starts with the definition of research problem from the construction company, which leads to the research objectives and research questions. The literature review on lean construction and on trust aspect in construction projects is the foundation of the research hypotheses articulating the thesis. This leads to the research methodology designing: based on the literature review, questionnaire statements are built to assess the hypotheses on case studies trough a case study protocol. At that point, the research methodology applied in the selected case studies produces input for the analysis. The analysis is held within cases and also in a cross cases analysis by comparing the two samples. The results of the analysis compared with the hypotheses provide a general conclusion and answer to the research question. From the conclusion, recommendations to the construction industry and for further research are presented flowed by reflection of the research project.

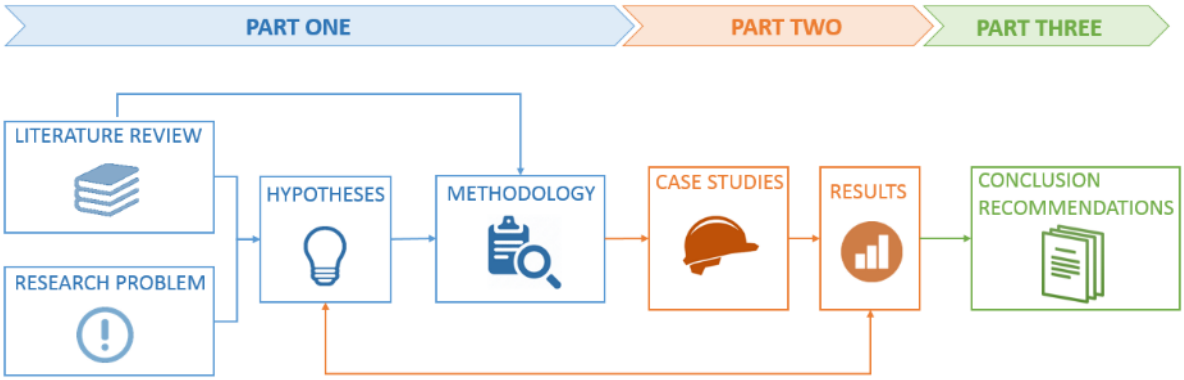

Figure 0-5 Structure of the thesis (own illustration)

Part One: Research Framework

"The best way to learn if you can trust somebody is to trust them"

Ernest Hemingway

This chapter presents the research framework of the thesis first by describing the research problem which leads to the research question and objectives. The third part is dedicated to the theoretical framework composed by the literature review and the formulation of the research hypotheses. The last section described the methodology of the research through the questionnaire's statements and its application.

1. Research problem

Initial Observations

Bouygues construction, a French construction company, is willing to improve the performance of building projects and starts developing the Lean Construction approach in its accommodation branch in Paris area called Habitat Résidentiel. This entity leads currently about 35 building projects and has a turnover of €300 million. They want to improve the performance of building site and especially regarding planning. Indeed, they have noticed an important waste of resources due to planning issues (e.g. misunderstanding on planning, delays of subcontractors that block the works of other subcontractors, non-conformity with the delivery planning, etc.). Those issues impact intrinsically not only the planning and time aspects but also the quality and the budget of the project.

They have already tested Lean Construction approach on eleven building sites and now they would like to deploy it to all projects. The results from the pilot projects are mitigated and regarding some aspects some adjustments need to be implemented to optimize the Lean Construction approach. Based on the experience feedbacks, the trust relationships among the project's actors seem to have a significant influence on the performance of the project.

The company's objectives of the Lean approach

The Lean planning approach was launched in 2015 to optimize the planning aspect of the all trades coordination. The first objective is focused on the client satisfaction by saving time, improving quality and controlling the project more closely. The second objective deals with the promotion of the professional excellence through optimization of schedule, anticipation of issues and maintaining a nice working atmosphere. The third objective concerns the development of collaboration among project actors by promoting frequent and open communication, mutual commitments and problem solving process. The Figure 1-1 shows the three main objectives of the company towards the lean approach (BouyguesConstruction, 2014b).

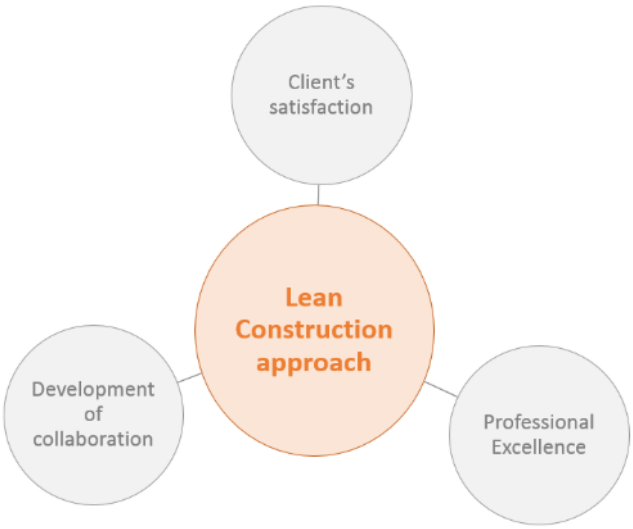

Figure 1-1. The three main objectives of the Lean Construction approach

Scope of the research

The research will be only focused on the planning issues in trade works stage of the projects when the structural works are completed. The accommodation building projects have two phases in Bouygues group: structural works, which are executed by the company's field workers; and the trade works, which is mainly executed by sub-contractors (e.g. painter, plumber, etc.). During this phase, the high number of subcontractors leads to an arduous coordination of works on site. Indeed, while the structural works are precisely planned, the company had noticed a huge waste in this second phase especially regarding project time performance. At this stage of the works, the large number of actors involved in the process makes trust aspects essential. Subsequently, the research will be only dedicated on the second phase of the projects.

Figure 1-2. Chronology of an accommodation building project

The research will be centered on construction project in Paris area in which the contractor is Bouygues Batiment. The contractual binds between the subcontractors and the contractor are according to Bouygues' legal policy and are similar in all its construction projects. Thus, the research will not be focused on contractual matters.

2. Research question and objectives

2.1. Research objectives

The research objective is to analyze the implementation Lean planning tools in building projects and its impact on trust relationships among actors and project time performance. The conclusion of the analysis will provide recommendations to project managers with regards to improve the management and the performance of building projects considering trust aspect.

2.2. Research question and sub-questions

The main research question of this paper is:

> ***To what extent does the implementation of Lean planning tools influence time performance of building projects through the improvement of trust relationships?***

To structure the research and to help answering the main research question, this study is guided by three sub-questions.

1. *How can trust aspects and project time performance be assessed towards the degree of lean planning tools implementation?*

2. *How does the implementation of Lean planning tools influence the trust relationships between the contractor and the subcontractors and among the subcontractors?*

3. *What is the impact of trust aspect on the project time performance?*

The first sub question is focused on the methodology and the research protocol to assess trust aspect and time performance of projects in relation to the degree of lean planning implementation. The second one is oriented towards trust aspect between two specific project's actors: the contractor and the subcontractor. The third research sub question deals with the project time performance.

3. Theoretical framework

In this section, a selection of relevant articles for the research design is presented as a starting point for further research. The first part of this section is dedicated to the Lean Construction from definition to implementation and its impact on construction project. The second part is oriented towards trust aspects of Lean Construction. Based on the literature review, five hypotheses will be presented in the third section of the theoretical framework.

3.1. Literature review on Lean Construction

1950-1980- From the Japanese automotive industry to the Lean Thinking

The lean principles come from the Japanese automotive industry developed after the Second World War. Ohno (1988) and Shingo (1988) described the main principles behind the Toyota Production System: eliminating waste by reducing set-up time, define small batch of product, cooperation with supplier, etc. Seven kinds of waste had been identified: (1) defects in products; (2) overproduction of goods: (3) inventories of goods awaiting further processing or consumptions; (4) unnecessary processing; (5) unnecessary movement of people; (6) unnecessary goods transportation; (7) waiting time. Womack and Jones (1996) have transposed the lean principles from Toyota production system to manufacturing industry abroad by defining five lean thinking principles exposed on Figure 3-1: (1) specify value from the customer; (2) identify the value stream; (3) make value creating flow; (4) achieving customer pull at the right time; (5) pursue perfection. They also added a source of waste to complete the seven type of wastes: failure of the design of goods and services to match user's needs.

Figure 3-1 Five-step process of Lean Thinking
Source: Lean Enterprise Institute

Since 1980– From Lean Manufacturing to Lean Construction

In the 1980's, the US manufacturing company started to implement the lean production techniques such as stopping the assembly line to repair the quality defects immediately, synchronizing and physically aligning all steps of the production process and pulling materials through the production system to meet specific customer demands (Tommelein, 1998; Womack & Jones, 1996). In the early 1990's researchers around the world began to study the applicability of the

lean principles to other industries such as food industry, hospitals, airlines and the construction industry (Paez, Salem, Solomon, & Genaidy, 2005). Besides the obvious wastes to be avoided in the construction sector, its applicability seemed challenging due to its characteristics such as one-of-a-kind product, site production, temporary organization, regulatory intervention (Koskela, 1992). He defined solutions to those particularities shown on Table 3-1. He said about the Lean Construction that 'advantages of the new production philosophy in terms of productivity, quality, and indicators were solid enough in practice in order to enhance the rapid diffusion of the new principles' (Koskela, 1992). The Koskela's theory on the application of the new production philosophy to construction sector is based on four key factors: (1) management commitment; (2) focus on measurable and actionable improvement; (3) involvement of employee and; (4) learning. According to Koskela the main barrier to implement Lean construction is the difficulty of management transplantation from manufacturing to construction industry, lack of international competition in construction industry and lagging response of academic institutions. Construction can be seen as an activity without taking into account the flow process design and improvement; which leads to substantial waste. It must be considered as a flow divided into the design flow process and construction process flow.

	Process Control problems	**Process improvements problems**	**Structural solutions**	**Operational solutions for the control**	**Operational solutions for the improvement**
One-of-a-kind	No prototype cycles Unsystematic client input Coordination of uncertain activities	One-of-a-kind processes do not repeat, thus long term improvement questionable	Minimize the one-of-a-kind content in the project	Upfront requirements analysis Set up artificial cycles Buffer uncertain tasks	Enhance flexibility of products and services to cover a wider variety of needs Accumulate feedback information from earlier projects
Site production	External uncertainties: weather etc. Internal uncertainties and complexities: flow interdependencies, changing layout, variability of productivity of the manual works	Difficulty of transferring improvement across sites solely in procedures and skills	Minimize the activities on site in any material flow	Use enclosures etc. for eliminating external uncertainty Detailed and continuous planning Multi-skilled work teams	Enhance planning and risk analysis capability Systematized work procedures
Temporary organization	Internal uncertainties: exchange of information across organization borders (flow disconnects)	Difficulty of stimulating and accumulating improvement across organization borders	Minimize temporary organizational interfaces (interdependencies)	Team building during the project	Integrate flows through partnerships

Regulatory interventions	External uncertainty: approval delay	Compression of approval cycle Self-inspection

Table 3-1 Overview on construction industry's peculiarities and corresponding solution from Koskela (1992)

From Howell's perceptive 'Lean construction is much like the current practice as the goal of better meeting customer needs while using less of everything' (Greg; Howell, 1999). Ballard defined the lean construction as "maximize the value and minimize the wastes while delivering the project" (Ballard, 1997). A similar definition was drawn by Koskela, Howell, Ballard, and Tommelein (2002): 'Lean construction is a way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value'. Yahya (2011) definition is more customer oriented: 'Lean construction is about managing and improving the construction process to profitability deliver what the customer needs by eliminating waste in the construction flow by using the right principle, resources and measure to deliver things right first time'. A variant of lean construction is more focused on sustainability: 'Lean Construction is a concurrent and continuous improvement to the construction project by reducing waste of resources and at the same time able to increase productivity and secure a better health and safety environment in order to fulfill the client's requirement as well as contributing towards sustainable and greener environment' (Marhani, Jaapar, & Bari, 2012).

Bertelsen and Koskela (2004) had defined to research stream concerning lean construction: (1) practical stream based on empirically study developing tools such as Last Planner System; and (2) the theoretical stream which started with the Koskela's (1992) analysis of the application of the new production philosophy to construction.

Paez, Salem, Solomon, and Genaidy (2005) worked on the sociotechnical framework of the transplantation of lean from manufactories to construction sites. They identified key elements to implement lean principles in the construction industry in a proactive approach of all participants: creative thinking, teamwork and problem-solving focus.

Failure of traditional construction project management

The traditional construction project management had been criticized by various researchers and its failure had been pointed out. G. Howell, Macomber, Koskela, and Draper (2004) associated the Fayol's theory about leadership to the traditional philosophy on project management. Fayol (1916) defined the foundation of the command and control model considering leadership as the ability to motivate the workers to perform the required tasks. They opposed the Fayol's theory to Flores' vision of project management who consider management as the ability to make and keep commitments: "Management is that process of openness, listening and eliciting commitments, which includes concern for the articulation and activation of the network of commitments, primarily produced through promises and requests,

allowing for the autonomy of the productive units" (Flores, 1982). Commitments require trust foundation which needs "a pattern of reliability in making and keeping promises, sharing common concerns and sincerity" (G. Howell et al., 2004). According to Flores, motivation is no longer external, but the willingness to perform comes from the promises and commitments: workers are responsible to watch over their interest and have the right to say "no". This is in line with the Toyota production system principles considering that defect must be not released downstream.

Cooper and Ellram (1993) highlighted the rework impact on construction project failure: he determined than there are from one-half to two and one-half rework cycle in the design of large construction projects. In the same way, Ballard and Howell (1998) found out that in traditional managed construction project the typical realization rate is 50-60% for weekly tasks. This is rate can be explained by various sources such as missing resources or logistics issues. Concerning planning matter, Applebaum (1982) described the duality of the construction management: the management function and the work execution. He said that "the two organizations do not coordinate their work, and they are characterized by different goals and viewpoints". This leads to planning distortion on site and impacts the project performance of the project. With the same idea, Fondahl (1980) pointed out that it is almost impossible to maintain an up-to-date plan on site because it fails to be dynamic: in most cases only the initial plan is ever produced in construction projects. He recommends to go down to the lower-echelon managers and to concerned subcontractor to provide "updated start dates, details on the methods and resources utilization, and current activities duration estimates". Koskela et al. (2002) identified the traditional project management failure: "in the present big, complex and speedy projects, traditional project management is simply counterproductive; it creates self-inflicted problems that seriously undermine performance". For instance, tasks start without all the needed inputs and prerequisites leading to low efficiency, low task continuity and increase the variability downstream. They also highlighted the lack theory on construction project management in comparison with practice development.

Hjelmbrekke, Hansen, and Lohne (2015) focused their research on the performance of construction projects. They figured out that the strategy-to-performance gap is more important with external suppliers. They identified three main sources of failure in construction projects: (1) divergence between the project owner's strategy and the concrete requirement; (2) project team is torn between different loyalties; (3) user requirement is rarely taken into account. Pinto and Mantel (1990) identified three approaches developed to avoid project failure: (1) development of decision rules or decision support system; (2) set of indicators and (3) association of the project success to several critical implementation factors. Using the last stream, they had investigated on the project failure measure factor influence: concerning construction projects the lack of technical expertise and the lack of adequate trouble-shooting mechanism seems to play a predominant role.

Differences between traditional project management and lean construction

Zimina and Pasquire (2012) had identified the main differences between the lean construction approach and the traditional project management summarized in Table 3-2 below.

Lean Construction	Traditional PM
Focus is on the production system	Focus is on transaction and contracts
Considers tasks, flow and value	Considers task goal
Downstream stakeholders are involved in upstream decisions	Decisions are made sequentially by specialist and imposed to downstream stakeholders
Product and process are designed together	Product designed is completed, then process design starts
Learning is incorporated into project, firm, planning and supply chain management	Learning occurs sporadically
Stakeholder interests are aligned	Stakeholder interests are not aligned
Buffer are sized and located to perform their function of absorbing system variability	Participant build up large inventories to protect their own interests
All product life cycle stages are considered in design	Not all product life cycle stages are considered in design
Activities are performed at the last responsible moment	Activities are performed as soon as possible
Systematic effort are made to reduce supply chain lead time	Separate organizations link together through the market, and take what the market offers

Table 3-2. Comparison between the lean Construction and the traditional project management approaches (Zimina & Pasquire, 2012)

Critics of Lean Construction

Green (1999) criticised the Lean construction approach in his article 'The Dark side of the Lean Construction: exploitation and ideology'. He decried that the lack of neutrality and criticality reflection from the Lean construction researchers. From his perceptive, the lean approach promotes the 'hegemony of management over labour'. Lean Construction should be more related to broader social, moral and political matters. He also believed that while the concept of Lean is from Japan and based on consensus, empowerment and loyalties, the main literature comes from the West and is more orientated towards management-by-stress and exploitation.

Howell and Ballard from the Lean Construction Institute wrote an answer to Green's article. They believed that Green missed the concept of Lean Construction. They consider that workers under lean earn more, have more autonomy: lean enriches their jobs regarding decision making, multi-skilling, pursue of perfection. They argued lean contributes to the accident reduction in the construction industry.

Wandahl (2014) warned on mis-conceptualization and mis-implementation of Lean Construction such as Last Planner system implemented partly or wrongly and lack of communication, education and knowledge.

Implementation of Lean Approach

The leadership is an essential aspect of the project management: two divergent visions had been exposed above in this section comparing Flores and Fayol theory on leadership. The implementation of lean leadership is complex and needs to deal with human relations among project's actors. Pamfilie, Petcu, and Draghici (2012) highlighted the importance of leadership in organization management for the implementation of Lean approach. Considering Lean Six Sigma as a business model, they had determined the key factors to create an adequate framework for Lean

strategy based on questionnaires methodology: efficient communication and driving the employee's satisfaction and motivation to increase the involvement in the continuous improvement process. Concerning Lean leadership, Dombrowski and Mielke (2014) defined 15 rules for a sustainable Lean Implementation based on five principles of Lean Leadership: (1) improvement culture; (2) self-development; (3) qualification; (4) Gemba (i.e. decision based on first-hand knowledge); (5) Hoshin Kanri (i.e. customer focus, aligned goals at all levels).

However, lean management in the construction industry is not only about leadership. Several studies present the results of lean implementation all over the world. Sacks (2007) suggested an example of the implementation of Lean Management in the Construction industry for building apartment. They started to analyse the current situation, identifying seven kinds of waste in Lean Construction approach: (1) *undesired products*: e.g. standard design apartments do not match with the commercial demand); (2) *rework*: e.g. repair of damages done by successive contractors; (3) *inventories*: e.g. materials are delivered per suppliers not per apartments; (4) *unnecessary movement of workers and/or materials*: stop of work due to lack of information implying the subcontractors need to come back later; (5) *unnecessary activities*: e.g. protection of incomplete work with door lock for instance; (6) w*aiting for materials or information*; (7) p*roducts that do not meet clients' needs*: e.g. when the commercial price of customization is prohibitive. The researchers have also adjusted the planning to reduce those wastes after defining the batch size as a single apartment and the work flow depending on the stable information from the client's requirements. In addition, multi-skilled workers decreased unnecessary movement and rework. A successful implementation of lean management appeared to need fundamental changes in design, procurement, planning and training. In China, Gao and Low (2014) had studied the construction industry through interviews and surveys. They concluded that the construction industry should implement the Lean Construction management in a systematic way as a process-oriented initiative within a socio-technical context. The researchers have found that the lack of commitment of different stakeholders was an important barrier to the implementation of the lean approach. Thus, the organization should change in mindset; it might be through a new organization culture. In order to achieve this, they advised the company to understand and reflect on their SWOT analysis.

Lean construction also deals with sustainability: Nahmens and Ikuma (2012) analyzed the effect of lean on sustainability through case studies in modular home manufacturing environment. They found out that the lean impacts the three dimensions of sustainability: (1) *economic aspect* by reducing the cost and increasing the profit; (2) *social aspec*t by improving working environment and workers health and; (3) *environment aspect* by reducing waste and optimize resource usage.

Lean Construction Tool: Last Planner System (LPS)

The Last Planner theories influence the planning, execution and control phases. The last planner represents the last person or group of person who are responsible for the individual task completion at the operational level. (Aziz & Hafez, 2013, p. 685).

The concept of the Last Planner System is based on the five integrated elements developed by Ballard (1997):

1. *Master Plan*: it gives a global vision of the project planning showing the main activities, their duration and sequence.
2. *Phase Planning*: it shows a divided version of the master plan into phases bridging the gap to the look ahead planning. The phase shows a more detailed work plan and provides goals to the project team.
3. *Look ahead Planning:* it is focused on a short-term period (up to 6 weeks). The main goal is to make task ready to start, removing all constraint and making it flows smoothly by replacing the reactive firefighting by a proactive problem solving.
4. *Weekly work planning*: it develops the look ahead planning into a more detailed weekly work plan. The performers assume responsibilities and give promises for the week to come.
5. *Feedback statistics*: it includes collecting data on the progress of the works through for instance the percentage of promises completed and registers the reason of non-completion.

The LPS concept developed by Ballard is presented on Figure 3-2.

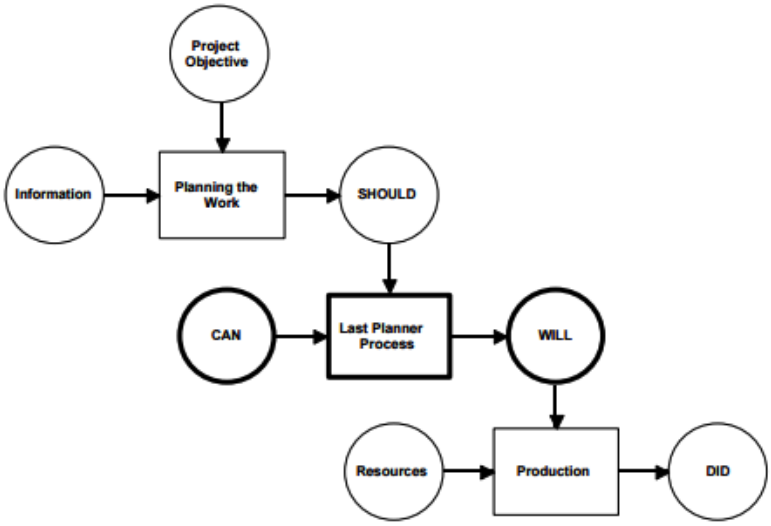

Figure 3-2 The Last Planner concept of Ballard
(Ballard, 1997)

According to Ballard, Tommelein, Koskela, and Howell (2002), the LPS of production control has three main components: (1) *look ahead planning*, including shaping the work flow sequence and rate, matching the work flow and capacity, maintaining a backlog of ready work, developing detailed plan for how work is to be done (operation designs). Concerning the implementation, specific tools can be used such as the constraint analysis and ADM (Activity Definition Model), which gives primary categories of constraint e.g. directive prerequisite work and resources. The second component is (2) *commitment planning*. It defines criteria for making quality assessment. A weekly Work Plan (WWP) is a relevant tool regarding the commitment planning. The last aspect is (3) l*earning* through feedback loops.

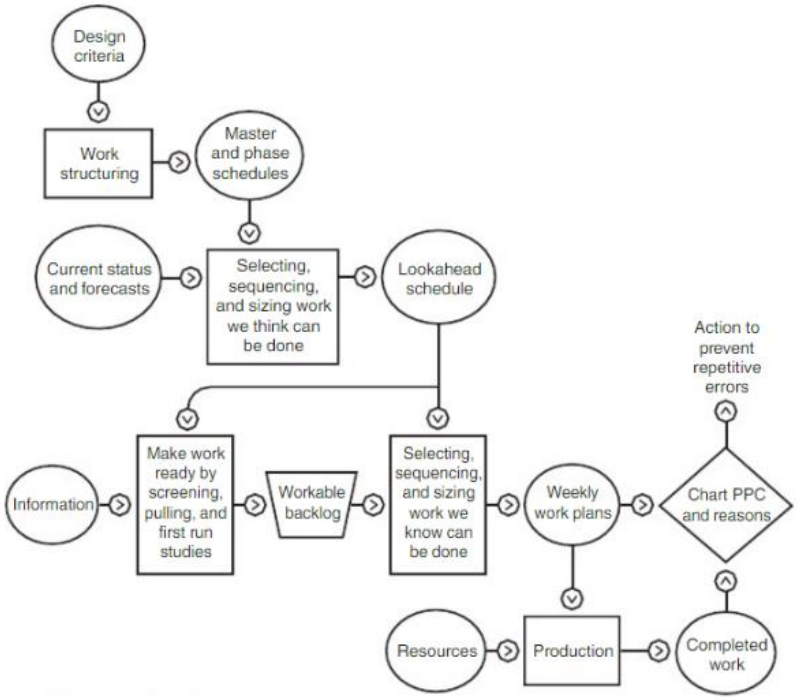

Figure 3-3 Last Planner System of production control
(Ballard et al., 2002)

> *"Observing the last planner projects we have learned that the "head" is not smarter than the body"*
> (Macomber & Howell, 2003)

The LPS is based on five key principles: (1) ensuring tasks are planned in increasing detail the closer the task execution approaches; (2) ensuring tasks are planned with those who are to execute them; (3) identifying constraints to be removed on the planned task beforehand; (4) ensuring promises made are secure and reliable; and (5) continuously learning from failures that occur when executing tasks to prevent future reoccurrence (Daniel, Pasquire, & Dickens, 2015, p. 154). The main advantages of this tool are its low maintenance, its flexibility to variability. It provides a planning based on independencies applying common sense and focusing on managing workflow. In addition, it promotes horizontal and vertical involvement of stakeholders (Aziz & Hafez, 2013, p. 688; Kalsaas, Grindheim, & Laeknes, 2014, p. 643). The LPS requires schedule understanding such as the reverse phase scheduling, look ahead schedule to control the work flow, variance analysis based on cost variance performance indicator and percentage plan completed charts (Salem, 2006, p. 171).

The results from previous studies on the implementation of LPS are quite positive. Fernandez-Solis et al. (2013) identified benefits: smooth work flow, predictable work plans, reduced cost, reduced time of project delivery and greater collaboration with field workers and subcontractors. However, LPS project participants faced some challenges such as lack of leadership, resistance to change,

> *"Implementing LPS is not simply applying a tool to a project, but changing the way people think, work and execute task"*
>
> (Hamzeh, 2011)

organizational inertia and contractual issues. Daniel et al. (2015) studied the implementation of Last Planner System through the International Group for Lean Construction's experiences. They have noticed that Last Planner system is a dynamic tool that is adjusted to the project context and requirements. For this reason, an integration of different lean tools such as LPS, BIM and takt time planning will be successful. In the same way, Dave, Hamalainen, Kemmer, Koskela, and Koskenvesa (2015) suggested a robust theory on planning and scheduling integrating different lean tools such as Last Planer System and Line of Balance for instance. They had identified LPS challenges: lack of continuity in task and flows, inadequate interface between schedule resolutions, lack of integration of scheduling and planning as part of the continuous improvement.

Macomber and Howell (2003) studied the linguistic action as the foundation for the design of lean project management. They made the link between the LPS as a distributed production control system that increase reliability in which the last planner had the responsibility to say "no" with the Ohno's rule concerning defects. Since projects are by definition promises to deliver including human endeavors and calling for performance of worker hand in hand, they argued that the worker's commitment is required to complete their tasks. They based their paper on a linguistic grammar of action composed by five different actions: (1) *declaration* creating a space of action; (2) *request* calling for a statement of commitment; (3) *promise* consisting of the statement of commitment; (4) *assessment* offering an opinion; (5) *assertion* consisting of a statement of fact. The LPS as a conversion-centered process helps the project team to make and elicit reliable promises which lead to reliable workflow. They defined the LPS as "a brilliant project management innovation that produces the routines for the ongoing articulation and activation of the network of commitment among responsible agent at every level" (Macomber & Howell, 2003)

As shown in this section, Lean Construction concerning planning is a very broad topic. In order to narrow the scope of the research project, an angle of research needs to be articulated around a specific aspect of Lean Management. Trust seems to be a relevant topic to investigate deeply the effect of Lean Construction in building projects. The next section introduces a literature review focused on trust in the context of Construction projects.

3.2. Literature review on trust aspect

Definition of trust

According to Oxford English Dictionary, trust as a noun is defined as:

- 'Firm belief in the reliability, truth, or ability of someone or something'
- 'Acceptance of the truth of a statement without evidence or investigation'

The definition of the verb to trust is:

- 'Believe in the reliability, truth, or ability of'
- 'Allow someone to have, use, or look after (someone or something of importance or value) with confidence'

Definition of trust in the context of projects

- 'Trust is a mental counter-part of delegation; structured set of mental attitude characterising the mind of a delegating agent' (Castelfranchi & Falcone, 2001).
- 'Trust is a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another' (Rousseau, Sitkin, Burt, & Camerer, 1998).
- Trust is the 'expectation of regular, honest, and cooperative behavior based on commonly shared norms and values' (Doney, Cannon, & Mullen, 1998).
- 'Trust is the degree to which the trustor holds a positive attitude toward the trustee's goodwill and reliability in a risky exchange situation' (Das & Teng, 1998).
- 'Trust exists in an uncertain and risky environment; trust reflects an aspect of predictability—that is, it is an expectance' (Bhattacharya, Devinney, & Pillutla, 1998).
- Trust is 'one's expectations, assumptions, or beliefs about the likelihood that another's future actions will be beneficial, favorable, or at least not detrimental to one's interests' (Robinson, 1996).
- Trust is 'the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party' (Mayer, Davis, & Schoorman, 1995).
- 'Trust is a matter of making and keeping commitment, and the problem of trust is not the loss of confidence but the failure to cultivate commitment making' (Solomon and Flores, 2001).

Trust as a key factor of project success

Trust is described as one of the main factors for collaboration with sub-contractors. Indeed, Chan and his colleagues considered the mutual trust among project participants as the first critical factor of partnering (Chan, Chan, Fan, Lam, & Yeung, 2006, p. 1929).

According to Beach et al., trust is an element of successful partnering as well as equity, management commitment, continuous improvement and mutual vision, goals and objectives (Beach, Webster, & Campbell, 2005, p. 615).

However, Eriksson and Laan (2007) identified that trust is overlooked by the construction industry in Sweden compared to authority and price aspects from a Transaction Cost Economics perceptive. They advised a more collaborative approach promoting trust-behavior and cooperation.

Kadefors (2004) identified a climate of distrust in traditional relational scheme between client and contractor in the construction sector due to for instance detailed contractual specifications and close monitoring of contractor performance. Indeed, those aspects tend to promote opportunism and hinder co-operative interaction. Anna Kadefors believes that a higher level of trust should enhance

project performance, especially concerning cross-disciplinary teamwork. Trust can be promoted through partnering measures such as economic incentive for cooperation – for instance open information sharing; formalized team building and join goal formulation - including not only time quality and cost goal but also soft goal as work process; and system for problem solving and continuous improvement.

Packham, Thomas, and Miller (2003) studied the partner relationships in the building sector from the point of view of subcontractors. They found out that key elements to successful partner relationship such as trust climate, mutual cooperation, team works and profit sharing, require a secure industry's future and balanced relationships. Indeed, unequal power relationships and limited range of contractual partners (for small construction enterprise for instance) lead to decline or failure of the partnering concept of common goal, increased profit and reduced costs.

Complexity of trust

Trust is a complex concept in a project context that includes different attributes such as competency, problem solving ability, communication, openness, alignment, information flow, long-term relationships, compatibility and respect.

Wong and his colleagues highlighted two main critical factors of trust: performance, including competences of partners, problem solving ability; and permeability, reflecting the openness of partner in sharing information. They considered the trust issue as a prisoner dilemma with two-party non-constant sum game in which the contractor should be the trust initiator. They believe that trust cycle needs to be kick-started by a trust driver (P. Wong, Cheung, & Ho, 2005, pp. 1046-1047).

Smith and Rybkowski elaborated a literature review on trust concept in construction projects. They underlined the diversity of aspects regarding trust: trust can be cognitive in opposition to affect-based, or it can be interpersonal in opposition with inter-organizational for instance (Smith & Rybkowski, 2012).

Besides trust aspect, some sources of mistrust had been identified in the construction industry such as misalignment of measurement and rewards, incompetence, lack of appreciation of a system, untrustworthy information and failure of integrity (Cheung, Ng, Wong, & Suen, 2003, pp. 336-337). According to Cheung and his colleagues, the project's stakeholders need to fix the sources of mistrust through partnering tools and project purpose to achieve trust.

Doney et al. (1998) studied the development of trust. They found a link between the National culture, norms and values and the cognitive processes of trust. They identified five trust-building processes: (1) *calculative*: individuals want to maximize their interest; (2) *prediction*: individuals' behavior is predictable; (3) i*ntentionality:* evaluation of target's motivation; (4) *capability*: based on the competence of individuals; and (5) *transference*: based on the network connection of individuals and institutions. In addition, Doney and her colleagues divided the national culture into three clusters: relation to authority, relation to self and relation to risk. Those clusters and the five trust-building processes can be related to the culture dimensions of Hofstede. For instance, individualism dimension impacts positively on calculative and capability processes and on relation to self.

Models of trust

Diverse models of trust had been developed by researchers based on different perceptive highlighting the diversity of this complex concept.

Rousseau et al. (1998) distincted three kinds of trust: (1) c*alculus-based trust*, considering that trust is led by economic incentive or self-interest; (2) r*elational trust*, considering that trust is based on a repeated, and direct relation between parties; (3) i*nstitution-based trust,* considering that trust is promoting by legal, cultural and societal norms. F. T. Hartman (2003) described three different trust models: (1) *integrity trust* or ethical trust considering that one party will take into account other's interests; (2) c*ompetence trust*, based on the ability of one party to perform the work assigned; (3) i*ntuitive trust*, based on the emotional belief that one party can trust the intention and action of the other parties. Lewick and Bunker (1996) determined different types of trust in their paper: (1) d*eterrence-based trust*, considering trust embedded by the fear of sanction in case of violation; (2) k*nowledge-based trust*, considering that the knowledge of parties on each other makes their behaviors predictable; and (3) i*dentification-based trust*, considering that trust is based on mutual understanding of parties. Mayer et al. (1995) proposed a trust model settled on three interrelated perceived trustworthiness factors: benevolence, ability and integrity. The literature review on trust models is summarized in the Table 3-3.

Authors	Trust models	Definition
Luhmann, 1979	Personal Trust	This trust is based on the emotional bonds between parties.
	System Trust	This trust excludes emotional content and is based on the effective function of money or power exchange
Lewis, Weigert, 1985	Cognitive Trust	The cognitive trust is characterized by a high rationality base and low emotionality level based on "good rational reasons" why the object can be trusted.
	Emotional Trust	The emotional trust is characterized by the low rationality and high emotionality level and is based on the affect for the object of trust
	System Trust	The system trust is based on the functioning of the bureaucratic sanctions and safeguards towards the legal system
McAllister, 1995	Cognitive-based Trust	Cognition-based trust is related to the available knowledge: success of past interaction, extent of similarity and organizational context considerations.
	Affect-based Trust	Affect-based trust is based on the motives of demonstrating interpersonal care and concern rather than enlightened self-interest
Lewick and Bunker, 1996	Deterrence-based Trust	This trust is embedded by the fear of the sanction in case of its violation
	Knowledge-based Trust	This trust considers that the knowledge of parties on each other contributes to the predictability of their behaviours
	Identification-based Trust	This trust is based on the mutual understanding of parties
Rousseau et al., 1998	Calculus-based Trust	Calculus-based trust is led by economic incentives or self-interest
	Relational Trust	Relational trust is based on repeated and direct relations between parties: emotion and personal attachment contributes to trusting relationships
	Institution-based Trust	This trust is built on legal, cultural and organizational norms

Hartman, 2000	Competence Trust	This trust is based on the ability of the one party to perform the work assign
	Integrity Trust	Integrity trust or ethical trust is based on the consideration that parties take into account other's interest
	Intuitive Trust	This trust is based on the emotional belief that one party can trust the intention and action of the other parties
Kramer, 1999	Dispositional Trust	Trust is based on a general belief about other people from early trust-related experiences
	History-based Trust	Trust is based on history-dependent information and interaction
	Third Parties as conduits of Trust	Third parties are able to diffuse trust-relevant information as second hand knowledge
	Category-based Trust	Trust is based on the knowledge obtained from members of a social or organizational category
	Role-based Trust	Trust is based on the role in the organization rather than on specific knowledge about person's capabilities, dispositions, motives and intentions
	Rule-based Trust	Trust is based on the shared understanding of the system of rules regarding appropriate behaviour
Wong et al., 2008	Cognition-based Trust	Trust develops from the confidence built upon knowledge that reveals the cognitive bearings of an individuals or an organization
	System-based Trust	Trust is based on formalized and procedural arrangements with no consideration on personal issues
	Affect-based Trust	Trust is based on a sentimental platform describing the emotional bond that ties individuals to invest in personal attachment and be thoughtful to each other

Table 3-3 Literature review of the trust models

Assessment of trust

Since trust is based on cognitive aspect by definition, it is a complex concept that is arduous to measure. However, some researchers had created arbitrary scale and formulas to overcome this limit of quantification.

Castelfranchi and Falcone (2001) developed theory on trust in multi-actor system: they associated trust as a mental state with delegation of an action. They define strong delegation as "Y's awareness of X's intention to exploit its action normally based on Y's adopting X's possibly after negotiation concluded by some agreement and social commitment" where X is the client and Y the contractor. They found a formula of degree of trust as a quantitative dimension of trust.

Based on the models of Hartman, Rousseau et al., and Lewick and Buncker's models of trust, Pinto, Slevin, and English (2009) assessed trust in 44 large infrastructure projects. To do so, they conducted a survey to contractors and project owners measuring competence trust on 4-items scale, integrity trust on 14-item scale, and satisfaction with working relationship using 7-item scale and project outcomes using 10-item scale. The results showed a deep interrelation between variables: working relationships influence the project success and they had noticed with a substantial indirect effect of integrity trust on the project outcome. They had also found a divergence between the contractor and the project owner regarding trust: for contractors only the integrity trust is significant on the project outcomes while both integrity and competence trusts matter from the point of view of the project owner.

From those examples of trust assessment, a method used by researchers consists of decomposing trust aspect into dimensions and attributes that are easier

to assess (Pinto et al., 2009; W. K. Wong, Cheung, Yiu, & Pang, 2008). The first step is to determine the more adapted trust models for the research design. This thesis project is centered on a working environment in the construction project management field. The Wong's trust models: (1) Cognition-based trust; (2) Affect-based trust and (3) System-based trust; appear to be relevant because it globally matches with the trust models developed by other authors and those three trust models are complementary in the research context. The Table 3-4 show the association of the trust models from the literature review to the three selected trust dimensions. Further explanation can be found in section 5.

Authors	Trust models	Dimension
Luhmann, 1979	Personal Trust	Cognition /Affect
	System Trust	System
Lewis, Weigert, 1985	Cognitive Trust	Cognition
	Emotional Trust	Affect
	System Trust	System
McAllister, 1995	Cognitive-based Trust	Cognition
	Affect-based Trust	Affect
Lewick and Bunker, 1996	Deterrence-based Trust	System
	Knowledge-based Trust	Cognition
	Identification-based Trust	Affect
Rousseau et al., 1998	Calculus-based Trust	Cognition
	Relational Trust	Affect
	Institution-based Trust	System
Hartman, 2000	Competence Trust	Cognition
	Integrity Trust	Cognition
	Intuitive Trust	Affect
Kramer, 1999	Dispositional Trust	Affect
	History-based Trust	Cognition
	Third Parties as conduits of Trust	Cognition
	Category-based Trust	Cognition
	Role-based Trust	Cognition
	Rule-based Trust	System
Wong et al., 2008	Cognition-based Trust	Cognition
	System-based Trust	System
	Affect-based Trust	Affect

Table 3-4 Scientific sources of the trust research dimension

3.3. Formulation of the hypotheses

From the literature review in previous section, five relevant hypotheses had been established to be confronted to the case studies during the research to answer the research question. The five hypotheses are described below and Figure 3-4 shows an overview of the hypotheses.

Hypothesis 1: The implementation of Lean planning tools leads to a greater level of trust between the contractor and the sub-contractors.

Hypothesis 2: The implementation of Lean planning tools leads to a greater level of trust among sub-contractors.

Hypothesis 3: Greater level of trust leads a greater project success concerning planning.

Hypothesis 4: The implementation of Lean planning tools leads directly to greater project's performance concerning planning.

Hypothesis 5: The implementation of Lean planning tools leads to greater project's performance concerning planning through other factors than trust aspects.

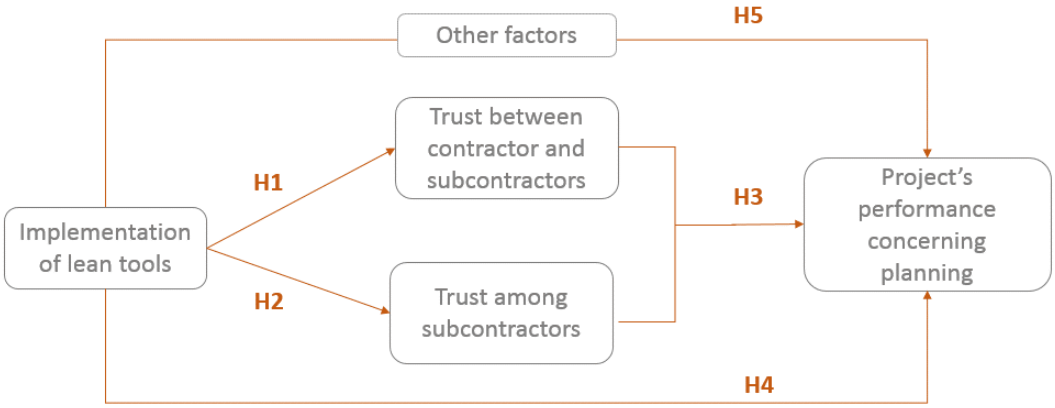

Figure 3-4 Overview of the five hypotheses

The two first hypotheses (H1 and H2) are dedicated to assess the trust relationships among the subcontractors and between the contractor and the subcontractors within projects. The third hypothesis (H3) focused on the connection between trust relationship among actors and the project's performance concerning planning. Those are the core hypotheses of the research to answer the research question.

The last two hypotheses (H4 and H5) are designed to exclude other and external factors and direct connection between the implementation of lean tools and projects performance towards planning aspects. Subsequently, the H4 and H5 are supportive hypotheses to the research hypotheses H1, H2 and H3.

4. Research approach

4.1. Case studies research strategy

The research strategy is based on case studies. Since a dozen of projects had implemented the lean construction approach in the company, a selection of case studies needs to be held to ensure the validity of the research results. The way of collecting data is open and deep with an overall picture of the implemented Lean planning approach through interviews of stakeholders (project managers, subcontractors, contractor team members, etc.), project reports (such as progress report, financial report and safety and health reports). The data availability is ensured by the company.

To provide a robust and rational validity (internal and external) and reliability to the research project, a case study data collection protocol is required (Yin, 2009, pp. 40-41). According to Yin (2009, p. 81), this protocol should include an overview of the case study project, a field procedures, case study questions and a guide for the case study report. The case study protocol is included in the methodology section and in the first section of the analysis part of the report. Moreover, three principles of data collection need to be followed. The first one is using multiple sources of evidence. The next section will emphasize on the sources of data and knowledge expected to be used in the research project. The second principle is creating a case study database to increase reliability. A notebook is dedicated to the master thesis research and a drive folder provides a backup copy of the thesis work and the sources used (document, scientific paper, etc.). Lastly, the third principle is to maintain the chain of evidence. In other words, it is necessary to keep link between the case study report and the caste study database, with the citation of sources, with the case study protocol and the case study question (Yin, 2009, pp. 114-122).

4.2. Research material

The source of data and knowledge will come from individual people, documents and literature and will be assessed through questioning, observation and content analysis as shown on Figure 4-1.

The scientific literature on lean construction, on construction project management and on trust aspects in the context of project is also important as knowledge source in order to provide the theoretical framework and define research hypotheses for the analysis phase.

Documents from “archives” are also a key sources of data and sometimes sources knowledge. In this research project, the available documents will be the monthly report of pilot project, the financial report and feedback report written at the end of pilot projects. The advantages of this kind of document are the quantity and the availability of data and the fact that there is no reactive behaviour. Nevertheless, the overwhelming amount of data can be a pitfall as well.

People will be interviewed and observed as source of data for respondents and informants such as subcontractors, project management team; and source of knowledge for expert (e.g. consultancy company). The data collection from people

has the advantages to be very diverse and with quite easy access within a company. However, it is necessary to be aware of the subjectivity of the formulation, the biased point of view of certain interviewees. The interviews were hold face-to-face as much as possible. Semi-open questions were privileged to leave freedom to the interviewee to answer the way he wants to and keeping a general framework.

Indeed, multiplying sources of evidence is important to provide a robust and rational reliability of the case study research methods. Triangulation on theory, data and methodology is essential to construct the validity of the research project (Yin, 2009, pp. 114-117).

Figure 4-1 ***Research material***
Adapted from Verschuren, Doorewaard, and Mellion (2010) and Yin (2009, p. 102)

The next section will explained how the research strategy is applied and the research materials is used in the research process.

5. Methodology

This section describes the construction of the research protocol. The first part deals with the research focus presenting the two sample groups used in the methodology: the research sample and the control sample. The second part is focused on the questionnaire from its references to the application procedure.

5.1. Research focus

Two sample groups

The five hypotheses described in section 3 will be assessed through a questionnaire conducted in seven projects mentioned below: four in which the Lean Construction approach had supposedly been implemented concerning the planning and three projects with an alleged traditional planning process. The last sample is the control sample to identify the impact on the lean approach on trust aspects and project's performance. The research sample will be compared to the controlee sample to find out the impact of the lean approach on the trust relationship among actors and its influence on the time performance of the project. In addition, the implementation of the lean concept need to be checked in both sample to ensure (1) the non-application of lean principles in the control sample and (2) the real implementation of lean principles in the research samples. The seven projects are more described in the part two of the master thesis report.

Research sample	Control sample
Case Study 1	Case Study 5
Case Study 2	Case Study 6
Case Study 3	Case Study 7
Case Study 4	

Table 5-1. ***The two sample groups***

Lean planning tool: Last planner system

As described in the literature review, the last planner system is a lean planning tool aiming at providing a collaborative planning and at making ready process. It is characterized by five key principles: (1) plan in greater details as you get closer to doing to work; (2) produce plan collaboratively with those who will do the work; (3) reveal and remove constraints on planned tasks as a team; (4) make and secure reliable promises and (5) learn from breakdowns (Koskenvesa and Koskela, 2012). Those characteristics are completely in line with the lean construction principles described in the theoretical framework and the last planner system can be considered as a representative lean planning tool.

In addition, the LPS principles structure the company lean planning approach described in appendix 1. Thus, it is supposedly applied in the research sample in which the lean approach had been implemented. For all those reasons the considered lean planning tool in this report is the Last Planner System (LPS).

5.2. Construction of the questionnaire

Based on the theoretical framework

The questionnaire is constructed on a theoretical framework of trust models. The Table 3-3 (in the theoretical framework section) shows literature review of the different trust models. The trust dimensions are very diverse but some similarities can be found. The questionnaire is based on the three Wong et al. (2008)'s trust models described below. Those three trust dimensions are complementary to each other and compatible with the other trust models developed by other authors as shown on the last column of Table 3-4 in which the closest dimension of the different trust models is identified.

- *Cognition based trust*: this trust is related to the available knowledge and the built confidence of an individuals or an organization
- *System-based trust*: this trust is based on the formalized and procedural content, excluding emotional or personal aspects
- *Affect-based trust*: this trust is related to the emotional bonds between people including emotional investment and thoughtfulness to each other.

Based on the literature review, each trust models had been decomposed into attributes as shown in the Table 5-2. The cognition-based trust includes two attributes: (1) interaction and information flows to determine how the interviewees interact and share information with other parties; and (2) competence – knowledge, to encompass the competence and the commitment to work of the other parties. The affect-based trust is decomposed into two attributes as well: (1) the thoughtfulness of the interviewee to the other parties especially considering the problem solving process with a constructive behavior; and (2) relational investment, to determine to what extent the interviewee considers the relationships with the other parties as individuals and beyond the working relationships. The system-based trust is split into two attributes: (1) the organizational policy, to focus on the organization's role in the trust relationships among actors; and (2) reputation, to reflect the historical and external factors influencing the trust building process among actors.

Model	Attributes	References
Lean tool	Degree of implementation	Ballard (1997), Zimina & Pasquire (2012)
Cognition-based trust	Interaction – Information flows	Wong and Cheung (2004), Wong et al. (2008)
	Competence - Knowledge	Pinto (2009), McAllister (1985)
Affect-based trust	Being thoughtful	McAllister (1995), Wong et al. (2008)
	Relational investment	Wong et al. (2008), Pinto (2009), McAllister (1995)
System-based trust	Organizational Policy	Wong et al. (2008), Wong and Cheung (2005)
	Reputation	Wong and Cheung (2005), Wong and Cheung (2005)
Project Time performance	Planning aspect	Pinto (2009), Wong and Cheung (2005)

Table 5-2 Overview of the structure of the questionnaire

As suggested in the research question, the project's performance will be only focused on time and planning aspects: mainly related to completion date and efficiency of the planning. Six statements are dedicated to the planning aspects: three are related to the third hypothesis and the two last ones are added to open the research by testing the fourth and fifth hypotheses. Indeed, the two last statements had been added to consider another link between lean tools implementation and the project's performance via another route than trust aspects.

As explained in the theoretical framework section, the questionnaire is also structured based on the three main hypotheses established in the previous section. Some statements will be focused on the trust relationship between the contractor and the subcontractors; some other statements on the trust relationship between the different subcontractors and the last part will be more oriented towards the projects' performance concerning the planning. Subsequently, for each statement, the influenced hypothesis is identified - in column three and four of the Table 5-3.

	Attributes	Hypotheses Contractor's point of view	Hypotheses Subcontractors' point of view	Statements	References
Lean tool	Degree of implementation	Lean	Lean	0.1/ The subcontractors had been involved in the planning process	Ballard (1997), Zimina & Pasquire (2012)
				0.2/ The project's actors commit to the results	
				0.3/ The planning is discussed at least every week	
				0.4/ Collaboration among actors is promoted concerning planning issues	
Cognition-based Trust	Interactions - Information flows	H1	H2	1.1/ I believe there is no hidden information from the subcontractors	Wong and Cheung (2004), Wong et al. (2008)
		/	H1	1.2/ I believe there is no hidden information from the contractor	
		H1	H2	2.1/ I believe I obtained more information from the subcontractors due to an open and honest communication	
		/	H1	2.2/ I believe I obtained more information from the contractor due to an open and honest communication	
		H1	H1	3/ I believe there were better understanding between individuals facilitated by frequent work-related interaction on site	
	Competence - Knowledge	H1	H2	4/ I am certain that other parties have the ability to perform productively	Pinto (2009), McAllister (1985)
		H1	H1	5/ I believe the project is managed in a good atmosphere	
		H1	H2	6.1/ I think the subcontractors approach their job with professionalism and dedication	
		/	H1	6.2/ I think the contractor approaches their job with professionalism and dedication	

Affect-based Trust	Being thoughtful	H1	H2	7/ I believe each party's needs were taken into account in decision making process to encourage a compromising and satisfactory outcome	McAllister (1995), Wong et al. (2008)
		H1	H2	8.1/ If I share my problems with the subcontractors, I know she/he will respond constructively and caringly	
		/	H1	8.2/ If I share my problems with the contractor, I know she/he will respond constructively and caringly	
	Relational investment	H1	H2	9.1/ The collaboration had been improved on site by maintaining a good and fair relationship with the subcontractors	Wong et al. (2008), Pinto (2009), McAllister (1995)
		/	H1	9.2/ The collaboration had been improved on site by maintaining a good and fair relationship with the contractor	
		H1	H2	10.1/ I am more likely to rely on a working partner (subcontractor) whom I have good impression as an individual person	
		/	H1	10.2/ I am more likely to rely on a working partner (contractor) whom I have good impression as an individual person	
		H1	H2	11.1/ I believe that long-term relationship with subcontractors maintain communication on site	
		/	H1	11.2/ I believe that long-term relationship with the main contractor maintain communication on site	
System-based Trust	Organizational Policy	H1	H1	12/ An effective (open and frequent) communication methods at work had been used on site to avoid ambiguous situations and discrepancies	Wong et al. (2008), Wong and Cheung (2005)
		H1	H1	13/ I believe job task required to individuals had been clearly defined	
		H1	H1	14/ The site management had reinforced goals achievement considering all stakeholder's interests	
	Reputation	H1	H1 (H2)	15/ I believe companies with higher reputation are more trustworthy as they do not want to lose their valuable asset	Wong and Cheung (2005), Wong and Cheung (2005)
		H1	H1	16/ I care about the reputation of my company during the project towards other parties	
Project Time Performance	Planning aspect	H3	H3	17/ The work process throughout the project is smooth and efficient (redundant work is eliminated) through collaboration	Pinto (2009), Wong and Cheung (2005)
		H3	H3	18/ Resolution of problem becomes more efficient. Stakeholder can make decision efficiently in problem solving	
		H3	H3	19/ The project can meet the committed target date for completion in a good working atmosphere	
		H3	H3	20/ The collaboration and the trust relationships among actors had impacted positively the project global schedule.	
		H4	H4	21/ The project's performance had increased due to continuous improvement of the work organization	
		H5	H5	22/ The project's performance had increased due to other/external reasons	

Table 5-3 Questionnaire statements

Two types of questionnaires

The questionnaire needs to be differentiated towards the interviewee's role in the project: either from the subcontractor companies or the contractor company. Thus the questionnaire will be split into two specific questionnaire: one for the contactors' interview and the other for the subcontractors' interview. Table 5-4 gives an overviews of the distribution of the questionnaires.

	Contractor questionnaire	Sub-contractor questionnaire	TOTAL
Lean	4	4	8
H1	16	14	30
H2	0	9	9
H3	4	4	8
H4	1	1	2
H5	1	1	2
TOTAL	26	33	59

Table 5-4 Overview of the distribution of the questionnaires

Questionnaire scoring system

Each questionnaire statement will be scored by the interviewee from 1 to 5 - 1 represents the case in which the interviewee disagrees with the statement while 5 means he or she agrees completely with the statement as described in the scoring scale on Figure 5-1 and Figure 5-2.

1: I strongly disagree with the statement
2: I disagree with the statement
3: Neutral
4: I agree with the statement
5: I strongly agree with the statement

Figure 5-1 Scoring scale

Figure 5-2 Example of visual support of the scoring scale

An example of the scoring system is shown below.

Statement #00: TU Delft is the best university

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Data collection method: interviews

Despite this questionnaire looks like a survey, it will be held as an interview in a face-to-face way. Indeed, it will allow to discuss the choice of the interviewees to provide more precision on their answer. The target groups of the questionnaire are on one hand the project team members (contractor company) and on the other hand, the foreman of the subcontractor companies. The script on the interviews can be found in appendix 2.

This part one was focused on the research framework starting with the problem definition, which led to the research objectives and research questions. The literature review on lean construction and on trust aspect in construction projects and the research approach helped to build the questionnaire statements included in the methodology section. Indeed, from the literature review three trust models were selected to assess trust aspect between the contractor and the subcontractors and among the subcontractors: (1) cognition-based trust; (2) affect-based trust and (3) system-based trust. To complete the questionnaire, the first section is designed to assess the degree of lean implementation and another section is drawn to evaluate the project time performance. This part provides the theoretical background of the research project that need to be applied to provide input to answer the research question. The next part of the thesis is focused on the analysis: first by operationalizing the methodology in the research protocol and then by highlighting the main trends per cases and in a cross-cases analysis.

Part Two: Analysis

"As for the future, your task is not to foresee it, but to enable it"

Antoine de Saint Exupéry

Based on the research framework presented in the last section, this chapter will be focused on the analysis of the Lean approach implemented in the company. The first section gives an overview of the research protocol. The second section highlights the results of the interviews per case studies, based on the questionnaire elaborated in the methodology section. The third part compares the results of the questionnaire of the two sample groups. The last section gives a discussion on the results.

6. Description of the research protocol

This section explains the research protocol applied in the research project based on the methodology. First the selection criteria of the case studies are presented. In the second part, the interview process is described and the third part is dedicated to the data analysis. The last section provides a synthesis of the research protocol.

6.1. Selection of the case studies

As explained in the methodology section in part one, the research includes two sample groups that represent seven projects: four projects with lean approach and three projects in which the lean approach was not implemented. To ensure those two groups, the degree of lean tool implementation will be assessed. The case studies will be considered only during the trade works for this thesis research. Thus the research framework excludes the structural works stage.

The project had been selected because they present a high degree of similarity:

- *Type of product*: repeating housing project with similar standards
- *Location* : Paris area
- *Contractual procedure* : the procedure of the contractor
- *Working organization* (e.g. administrative procedure, organization on site, etc.): the organization of the contractor
- *Historical relationships between the contractors and the subcontractors*: the subcontractors are mainly chosen from the contractor's data base
- *Technical approach*: based on the contractor's design and method department
- *Phase stage*: Trade phase

However, each project presents its own characteristics: for instance the size or specific logistic issues. Those differences are highlighted below.

6.2. Interview process

Each interviews took about half an hour and on average one day per project was dedicated to the interviews process. In specific cases in which interviewees were very busy, collective interviews were held with a couple of subcontractors during lunch time.

The interviews follow those steps:

- Brief introduction on my works on the planning process
- Questionnaire statements scoring
- Explanation of their answers if necessary
- Question on their vision of the potential improvement of the planning tool

The interviewees are chosen depending on their availability and their presence on site. Concerning the subcontractors, the investigations are focused on the site foreman - or the general foreman or owner of the subcontractor company if there were no site foreman - and concerning the contractor company, the works supervisors. In total, there were 58 questionnaire interviews: 23 from the contractor company and 35 subcontractors.

In addition to the questionnaire interview, the results were confronted to the project managers to ensure the validity of the results. The script of the interviews of the project managers can be found in the appendix 4.

6.3. Data analysis method

The data is collected on an excel sheet. The scores are given on weighted average on a five-item scale. The calculus tables are shown in the appendix 5. The hypothesis or trust model scores are weighted in accordance with

- The distribution of statements
- The number of interviewees per project and per type of questionnaire (contractor or subcontractor)
- The number of projects

Thus all the results are comparable on a five-item scale. The details of the questionnaire results are presented in the appendix 3 and appendix 5.

6.4. Synthesis of the research protocol

The research protocol is founded on the questionnaire described in part one. The questionnaire is based on the literature review and on the five highlighted hypotheses. Indeed this section is the operationalization of the methodology section in part one. The combination of the two sections provides an answer of the first research sub question.

> ***How can trust aspects and project time performance be assessed towards the degree of lean planning tools implementation?***

The questionnaire is structured to provide input towards the five research hypotheses. Subsequently, the first part of the questionnaire statement is dedicated to the assessment of the degree of lean tools implementation to distinguish the two groups of project; the second part is focused on the trust aspects assessing the two first hypotheses; the third part of the questionnaire aims at checking the project time performance; and the last part is orientated towards other potential routes from the lean tools to the project time performance. All the questionnaire statements are built on the literature review as explained in the methodology section.

The research protocol explained more practically how the questionnaire will be applied on the seven case studies: from the selection of the cases to the interviews process and the data analysis. The protocol is built to be as neutral as possible to avoid biased influence on the results.

The combination of the questionnaire and the research protocol provides the method to assess the project time performance and the trust aspects between the contractor and the subcontractors and among the subcontractors toward the implementation of lean tools.

7. Case studies

This section presents the seven cases: first by briefly describing the projects, secondly by presenting the main findings of the interviews (more details are shown in appendix 6), thirdly by showing graphically the questionnaire results and then by exposing their explanations.

7.1. Case study 1

Description

This project is composed by 330 dwellings and 2 commercial spaces divided in five 9-floor buildings. The works started on October 2014 and is expected to end in January 2017. Ten engineering site supervisors work on this project to manage the structural works and the trade works.

Figure 7-1 Case Study 1 building site

The main issue concerns the planning: the five buildings are built at the same time and need to be delivered for the same date. The coordination of the different subcontractors is thorny and needs to be studied carefully.

Due to the size of the project, planning is arduous and can become chaotic very quickly. The project was divided into three parts: the façade and the two groups of buildings as shown on the Figure 7-2 with the two circles. For each areas, a collaborative planning process had been started: every Thursday afternoon they organise a planning session.

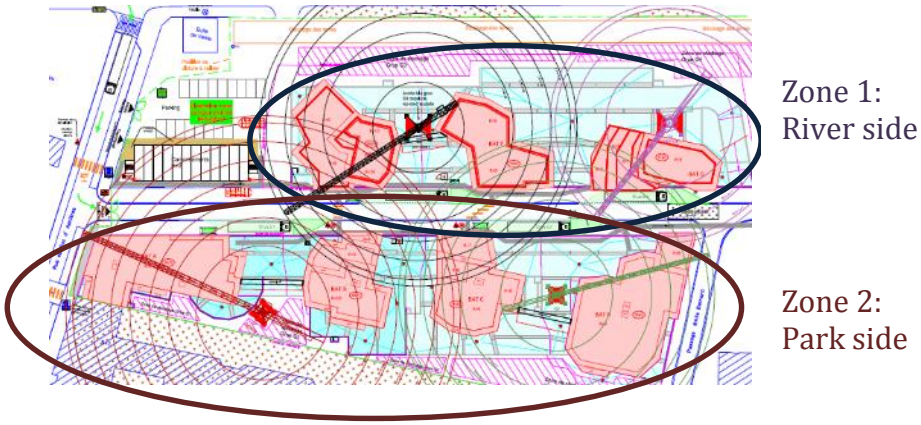

Figure 7-2 Division of the working space in case study 1

Main findings from the interviews

- *Contractors:* they focused on the difficulty of the planning management due to the size of the project. Since the contractor project team is very large, communication becomes a key element concerning planning issue especially inside the contractor team. They suggested to pick out a couple of the works supervisors dedicated to the planning as the "planning contact members" for subcontractors in order to improve the implemented lean approach. The contractor team believes that the lean approach has promoted the communication among subcontractors. A site supervisor advised to involve widely project's actors such as the architect and the client. Some member of project team argued that the planning meetings were too time-consuming.
- *Subcontractors:* The large number of subcontractors appears as a limitation of communication on site among subcontractors. Some subcontractors argued that planning meeting were not enough structured mentioning the quality issue from the structural works, which was the main highlight the week before the interviews. However, some subcontractors seemed to be convinced by the lean approach "it helps to prepare my works and anticipate changes". They all mentioned the Thursday meeting as an opportunity to communicate and to promote collaboration among project's actors.

Questionnaire results

The questionnaire results for this case study are presented on Figure 7-3 and Figure 7-4 below.

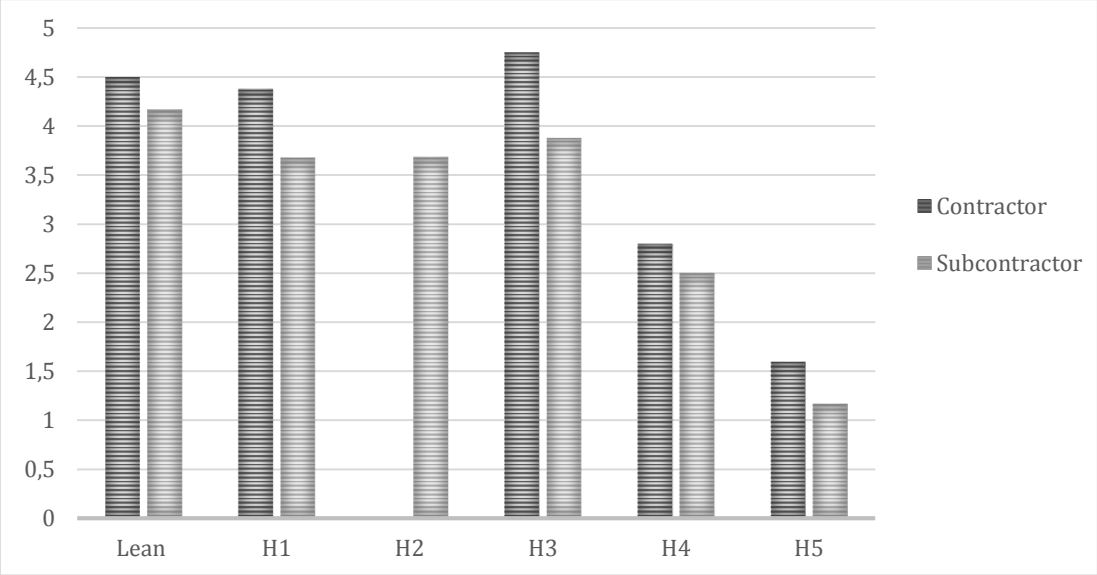

Figure 7-3 Results of the questionnaire for case study 1

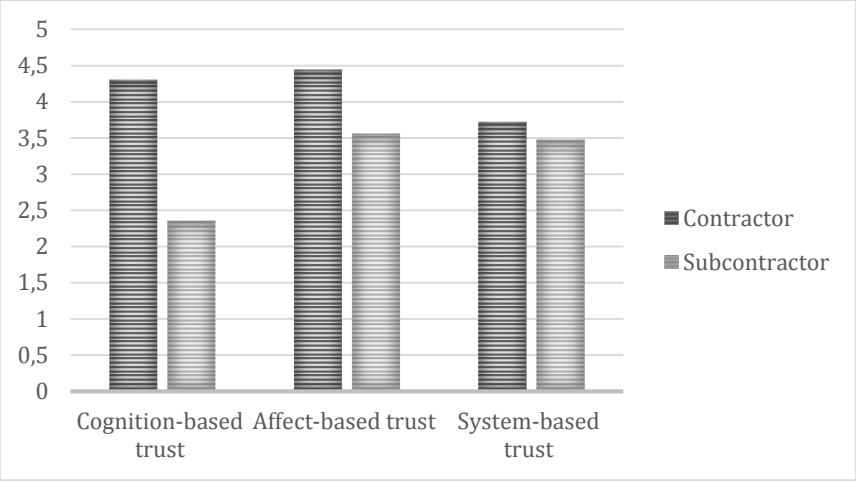

Figure 7-4 Results of the questionnaire regarding trust distribution for case study 1

Results analysis of case study 1

- *Lean implementation*: The degree of implementation of lean tools concerning planning is quite high which means the lean approach can be considered as implemented in this case study. Both points of view agree on comparable scores concerning the lean implementation.
- *Trust aspect*: The degree of trust between the subcontractors and the contractor (H1-related statements) is higher from the contractor's point of view than the subcontractors. Based on the trust distribution the main divergences are towards the cognition-based trust and to a lesser extent the affect-based trust. The cognition-based trust is assessed based on the competency and the information flow attributes. Subsequently, this divergence can be explained by the fact the contractor had selected the subcontractors mainly considering their competencies and not the other way around. Regarding the affect-based trust, the score difference is also linked to the selection process of subcontractor by the site supervisors: they choose subcontractor they used to work with and with whom they have a good relationships/feelings. Concerning the system-based trust, the two scores are very similar in both cases. In addition, it is noticeable that from the subcontractor's point of view, the scores related to H1 and H2 are quite similar: this means that the subcontractors consider their trust relationships equally towards the contractor's team members and the other subcontractors. In addition, the project manager underlined the difference of relationships nature: subcontractors had a contractual binding with the contractor, which does not exist with the other subcontractors.
- *Time performance of the project*: The two perceptions on the project time performance are slightly different: the subcontractors scored H3 lower than the subcontractors. This phenomenon is probably linked to the missing information from the subcontractor's side: the site supervisors seem to hide or adjust information to the subcontractors about the global project completion date for instance.
- *Other Factors*: The score of H5 are not high enough to be significant. However, the H4 scores (2.5 -2.8/5) are noticeable. According to the majority of interviewees, the continuous improvements are "as in normal

situation". Some subcontractors mentioned a new internal administrative procedure concerning the insulation certification.

7.2. Case study 2

Description

This project is quite small: only one building of 36 dwellings. Two engineering site supervisors are dedicated to this project. It has started in April 2015 by the demolition of three old houses. Diverse issues due to the neighbour's wall has impacted the planning at the beginning and caused some delays, but the structural works expect to catch up the initial planning.

The main issue concerns the availability of storage area. Indeed, the building project is very small and the tiny garden behind the dwellings is not sufficient to store all the necessary materials. Thus an effort needs to be made on the delivery schedule, which should match perfectly with the needs of the subcontractors.

Since the main issue concerns the logistic aspect. The planning had been created based on the delivery plan to check availability of the storage area by the time of the expected delivery. The projects had been divided into two main areas: the external trades (façade and vegetation trades) and internal trades concerning the dwellings (plumber, painter, etc.). Planning meetings are planned every Tuesday morning with the foreman of the concerned subcontractors and the contractor project team members.

Figure 7-5 Case study 2 building site

Main findings from the interviews

- *Contractor:* The two works supervisors had developed in combination with the collaborative planning, logistic tools to face the very limited stock space in this project. To improve the lean tools, both works supervisors advised to integrate logistic aspects in the collaborative planning process.
- *Subcontractors:* The subcontractors knew each other before this project; they used to work together on previous building projects. The atmosphere seems very friendly on site: they used to have lunch all together. The limited number of workforce seems to contribute to this atmosphere as well. They also noticed that the logistic played an important role in the planning. Subsequently they joined the suggestion of the contractor to integrate logistic aspect into the approach.

Questionnaire results

The questionnaire results for this case study are presented on Figure 7-6 and Figure 7-7 below.

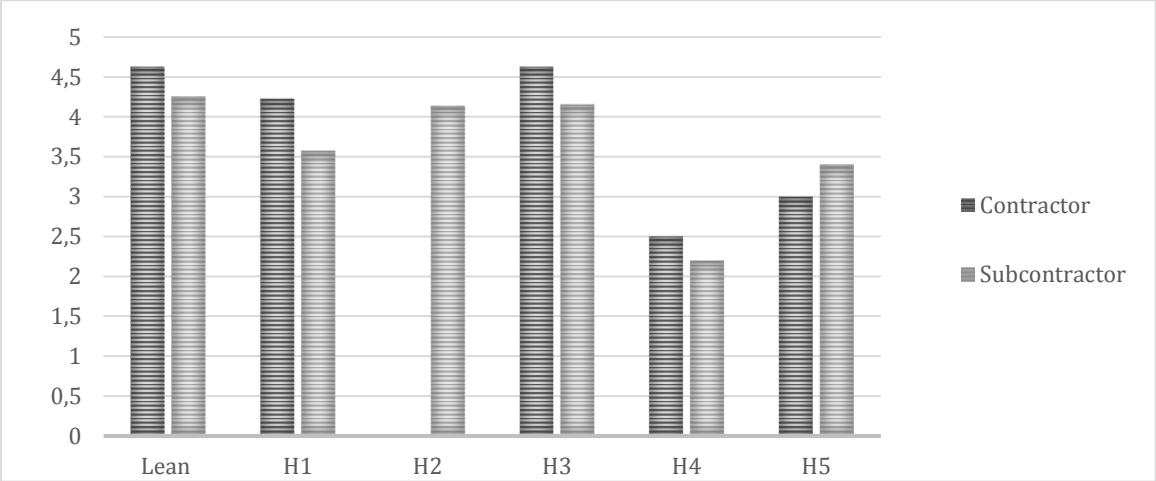

Figure 7-6 Results of the questionnaire for case study 2

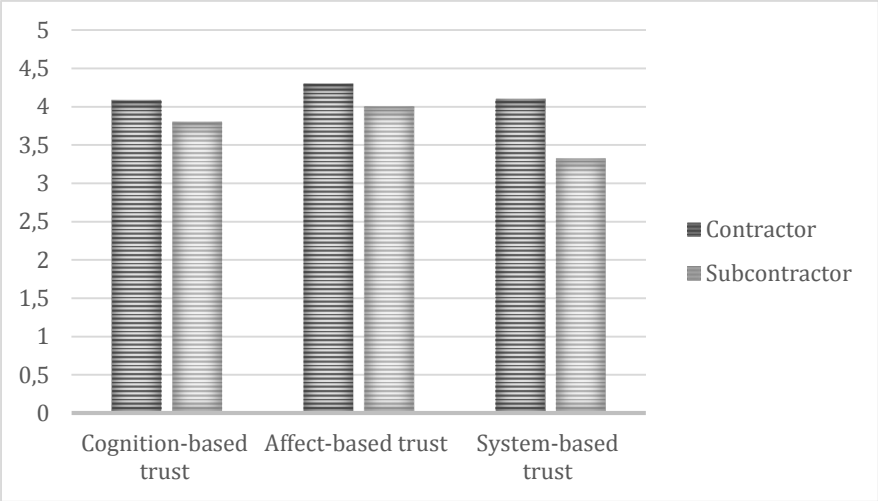

Figure 7-7 Results of the questionnaire regarding trust aspect for case study 2

Results analysis of case study 2

- *Lean implementation*: The degree of implementation of lean tools concerning planning is quite high from both points of view which means that the lean approach can be considered as implemented in this case study. The lean implementation score from the contractor's point of view is slightly higher than the subcontractors. This could be explained by the fact that the contractor was the imitator of the lean approach.
- *Trust aspect*: The degree of trust between the subcontractors and the contractor (H1-related statements) is higher from the contractor's point of view than the subcontractors. Based on the trust distribution scores, there is no major divergence between the two perspectives. Nevertheless, the system-based trust is slightly higher from the contractor's vision than the subcontractor's vision. The system-based trust is assessed through two attributes: the reputation and the organizational policy. Since the

organizational policy is built by the contractor, it is not striking to have this kind of score differences. In addition, it is noticeable that from the subcontractor's point of view, the scores related to H1 are higher than the H2-related scores: this means that the subcontractors consider to have stronger trust relationship with the other subcontractors than with the contractor. This phenomenon can be founded on the fact that subcontractors used to work together and thus the atmosphere on site among the subcontractors tends to be "friendly".

- *Time performance of the project*: The two points of view on the project time performance are slightly different: the subcontractors scored H3 lower than the subcontractors. This phenomenon is probably linked to the missing information from the subcontractor's side: the site supervisors seem to hide or adjust information to the subcontractors about the global project completion date for instance. However, the two time performance scores are quite high: 4.6-4.1/5.
- *Other Factors*: H4 and H5 scores are quite high from both sides due to the logistic effort of the contractor site supervisor team. Indeed, on one hand the logistic approach could be considered as an external factor because it is mainly towards supplier and delivery date but on the other hand logistic is intrinsically linked to the planning issues by ensuring the materials to perform works, so it can be considered as a continuous improvements. However, the high score in H5 and H4 related statement means that the project time performance scores are potentially influenced not only by the lean tools implementation but also by the logistic approach. Thus, the results concerning the time performance can be ambiguous towards its source in this specific case study.

7.3. Case study 3

Description

This project is composed by 110 apartments in 4 buildings. Three engineering site supervisors work on this project. The project started on February 2015 and is expected to end in November 2016. The schedule is a bit tight due to some delays during the structural works.

The only issue is the tight schedule. The client expects the four buildings finished by the end of 2016 and the structural works were longer than expected.

The project team has used a time-location schedule and use it every week during the collaborative planning session to check the progress of the project with the foreman of the concerned subcontractors. They used buffer management indicators.

Figure 7-8 Case study 3 building site

Main findings from the interviews

- *Contractors:* The project team used to work together. They do not feel that the lean approach helps that much their daily work concerning schedule but they do agree on the improvement of the communication among subcontractors. They noticed that beforehand subcontractors shared their problems through the contractor team which seems to be reduced thanks to the planning meetings. Their main critics concern the duration of the planning meeting: they believe it was too long and too chaotic to be constructive. They advise to make groups of subcontractors with high level of interactions. In addition, the façade works seem to be not totally compatible with the lean tools.
- *Subcontractors:* Most of the subcontractors used to work together except two main technical subcontractors. Interviewees look enthusiastic with the new approach and had the feeling to interact more with the contractor concerning decision-making. Some subcontractors are reluctant arguing it is time consuming: the plaster wall installer considers the planning meeting as a waste of time. In other words, the duration of the planning meeting is a major issue for the subcontractors. Earlier involvement of project's actor into the planning process had been suggested to reduce redundant works.

Questionnaire results

The questionnaire results for this case study are presented on Figure 7-9 and Figure 7-10 below.

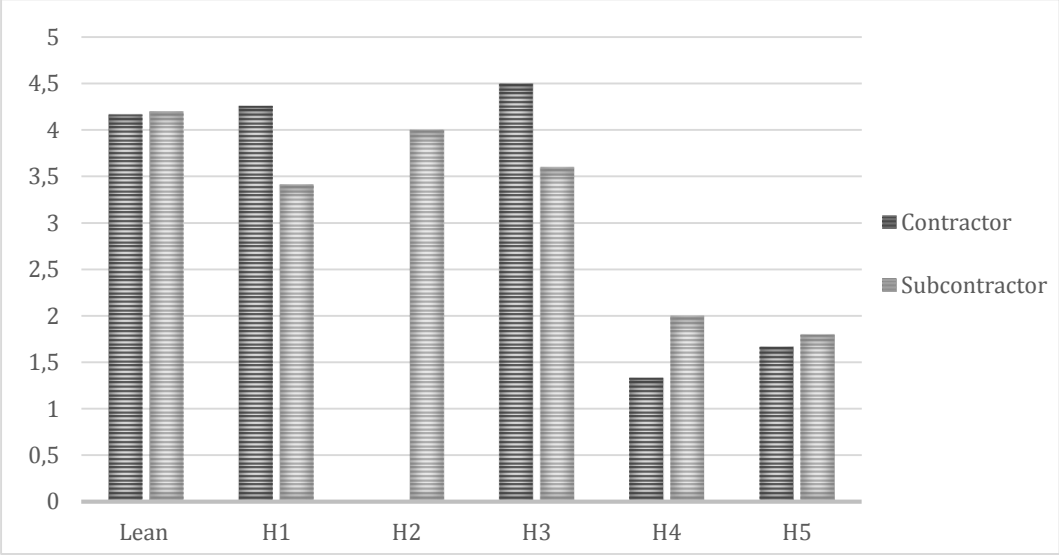

Figure 7-9 Results of the questionnaire for case study 3

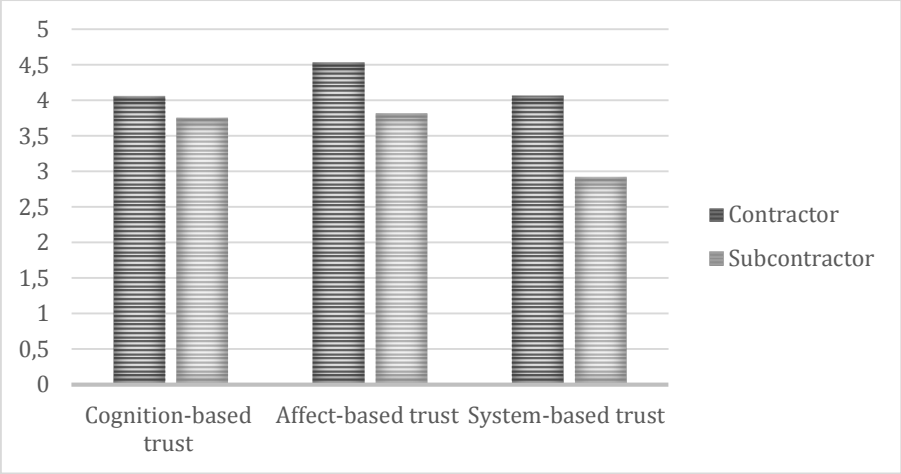

Figure 7-10 Results of the questionnaire regarding trust aspect for case study 3

Results analysis of case study 3

- *Lean implementation*: The degree of implementation of lean tools concerning planning is very similar and high from both points of view which means that the lean approach can be considered as implemented in this case study.
- *Trust aspect*: The degree of trust between the subcontractors and the contractor (H1-related statements) is higher from the contractor's point of view than the subcontractors. Based on the trust distribution scores, there are two major divergences between the two perspectives: affect-based trust and system-based trust are scored higher from the contractor's point of view. Concerning the affect-based trust, this trust model is divided into two attributes: being thoughtful and relational investment. According to the project manager, those scores can be explained by the relationships built between the contractor's team and the majority of the subcontractors all along: they used to work together since a couple of projects already. Concerning the system-based trust, this trust model is assessed through two attributes: the reputation and the organizational policy. Since the organizational policy is built by the contractor, it is not striking to have this kind of scores differences. Scores regarding the cognition-based trust are quite similar from both sides: it means that competency and information flow are not questioned. In addition, it is noticeable that from the subcontractor's point of view, the scores related to H2 statements are higher than the H1-statements-related scores: this means that the subcontractors consider to have stronger trust relationship with other subcontractors than with the contractor. According to the project manager, this phenomenon can be founded on the fact that subcontractors used to work together.
- *Time performance of the project*: The two visions on the project time performance are slightly different: the subcontractors scored H3 lower than the subcontractors. This phenomenon is probably linked to the missing information from the subcontractor's side: the subcontractors are not always aware of the global project completion date but are only focused on their trade completion date which are generated with a "safety" margin according to the project manager.
- *Other Factors*: H4 and H5 scores are not significant.

7.4. Case study 4

Description

This project is composed by two buildings of 4 floors: one is built to welcome young workers and includes small renting apartment (studio) and the other building is constituted by owner apartments. Three site supervisors work on these projects.

Figure 7-11 Case study 4 Building site

This project includes a technical issue on the roof construction made of wood. It requires longer time and it can impact the works inside the building by postponing the waterproof protection.

The project had been divided into two main areas: the small dwelling for young workers area and the familly appartment area. A time-location planning had been drawn based on the a collaborative planning preparation with the subcontractors. They have organised planning session every Friday morning with the concerned subcontractors. They planned to check, the progress of the project with the buffer management.

Main findings from the interviews

- *Contractors:* The lean approach was completely new for the works supervisors: they were quite doubtful at the beginning but after a couple of weeks applying the planning routine, they start to see results regarding the communication on planning issues and collaboration with the subcontractors. They believe the tool is more efficient in a repetitive units project such as student housing. They advised to simplify the lean approach for instance by reflecting on floors rather than apartments or student rooms.
- *Subcontractors:* The subcontractors are in a similar situation as the contractor in this project: the approach is new as well for them. The majority of the subcontractors seems convinced by the collaborative approach: they feel involved in the planning process since the early stages to the execution. They noticed the communication among the subcontractors had been improved due to a better understanding of the other "needs and constraints". However, a minority looks reluctant and admits to avoid planning meeting considering it as a waste of time.

Questionnaire results

The questionnaire results for this case study are presented on Figure 7-12 and Figure 7-13 below.

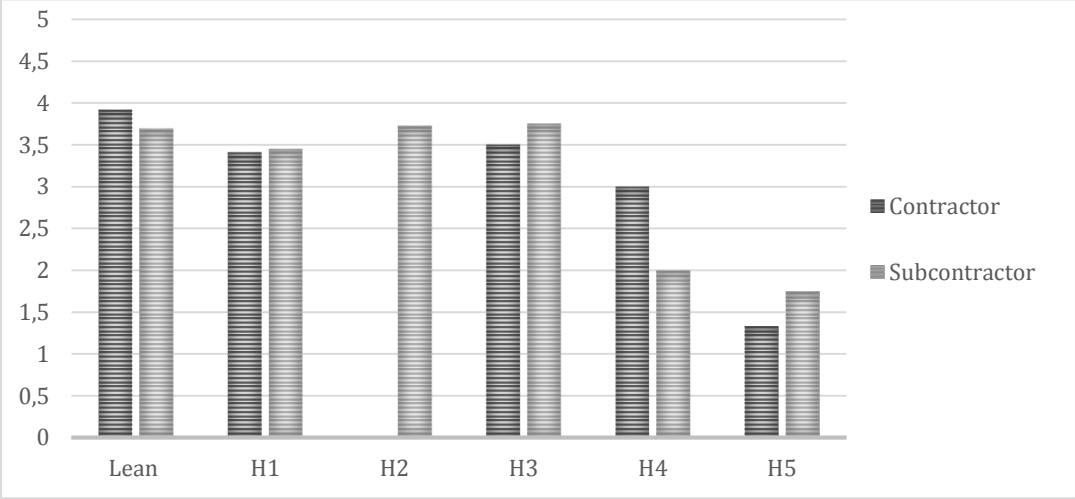

Figure 7-12 Results of the questionnaire for case study 4

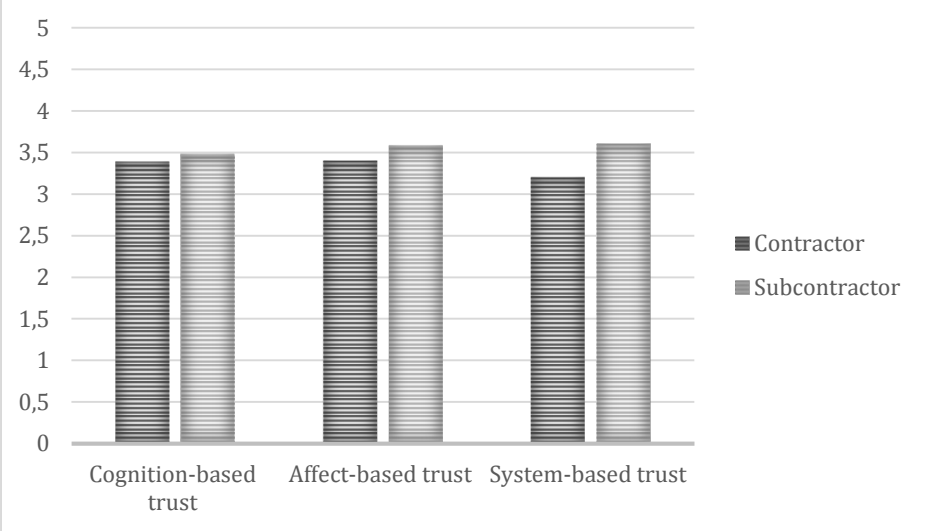

Figure 7-13 Results of the questionnaire regarding trust aspect for case study 4

Results analysis of case study 4

- *Lean implementation*: The degree of implementation of lean tools concerning planning is quite similar from both points of view. The scores are in the medium range of the scale. This leads to a questioning whether the lean tools can be considered as implemented or not in this specific case. However, by comparison with the "control sample" scores, this case study has a much higher degree of lean tools implementation. Thus the lean approach can be considered globally as implemented in this case study.
- *Trust aspect*: The degree of trust between the subcontractors and the contractor (H1-related statements) are very similar from both visions. Based on the trust distribution scores, there is no major divergence between the two perspectives. In addition, it is noticeable that from the subcontractor's point of view, the scores related to H2-statements and the H1-statements related scores are quite similar: this means that the

subcontractors consider to have equivalent trust relationships with other subcontractors and with the contractor.

- *Time performance of the project*: The two perceptions on the project time performance are quite similar: the subcontractors scored H3 slightly higher than the subcontractors which is relatively surprising. This phenomenon is probably linked to a lack of optimism from the site supervisors according to the project manager.
- *Other Factors*: H4-statement scores are higher from the perceptive of the contractor than from the subcontractor's perspective. This is explained by the new administrative procedure of the subcontractor's human management online considered as a continuous improvement. H5-statement scores are not significant.

7.5. Case study 5

Description

This project is composed by four buildings of 7 floors for 235 dwellings: it is built to welcome diverse users: business trip hotel, restaurants, kindergarten, renting apartments and owner-occupied apartments. Six site supervisors are working on this project.

This project includes a technical issue concerning its size compared with the limited available space around the site. In addition, the green spaces between buildings had seasonal constraints to be planted.

Figure 7-14 Case Study 5 site and model

Main findings from the interviews

- *Contractor:* The head of the works supervisors follows an old fashion management principles based on the hierarchy and fear of financial sanction. Subsequently, the relationships with subcontractors are quite authoritative centered on written communication to be able to prove each responsibility. They would like the subcontractors to be more transparent concerning planning issues to be able to reduce control and balance their relationships between the contractual frameworks and the objective of partnership.
- *Subcontractor:* The subcontractors used to work with the contractor team. They are focused on the protection of their interests not only regarding

planning but also regarding cost and quality. The phenomenon consisting of waiting as much as possible to avoid any interaction with the previous trades and then speeding up to catch up the contractual completion date of the concerned trade, is a relevant example of the state of mind of the subcontractors. They would like to be involved in the planning process earlier to promote better communication and collaboration among the project's actors.

Questionnaire results

The questionnaire results for this case study are presented on Figure 7-15 and Figure 7-16 below.

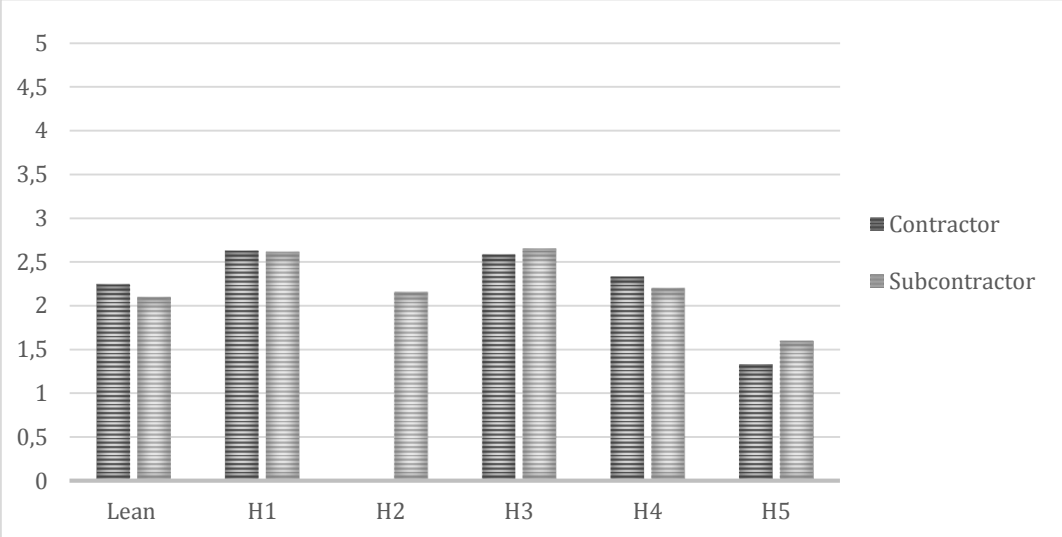

Figure 7-15 Results of the questionnaire for case study 5

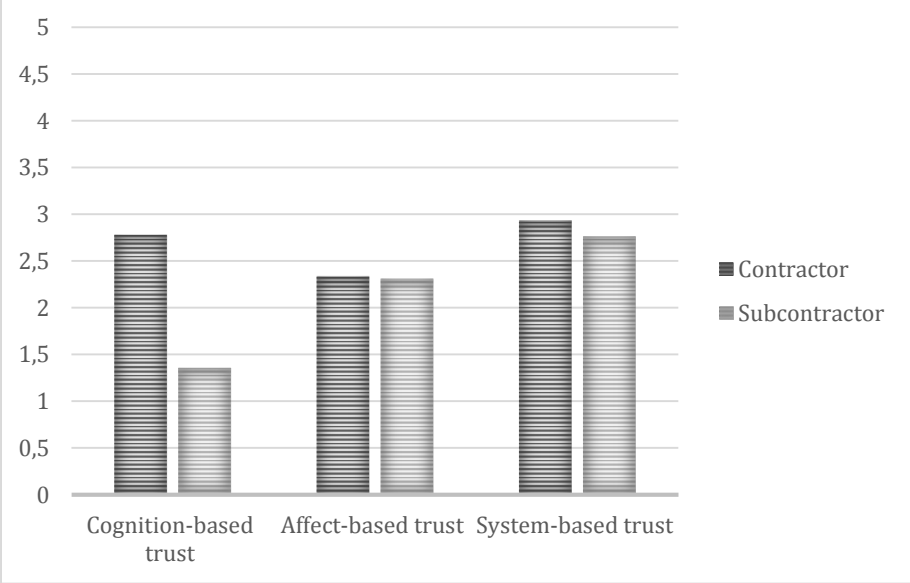

Figure 7-16 Results of the questionnaire regarding trust aspect for case study 5

Results analysis of case study 5

- *Lean implementation*: The degree of implementation of lean tools concerning planning is very similar and quite low from both points of view

which means the lean approach can be considered as non-implemented in this case study.

- *Trust aspect*: The degree of trust between the subcontractors and the contractor (H1-related statements) is quite similar from both sides. Based on the trust distribution scores, there is one major divergence between the two perspectives: cognition-based trust is scored higher from the contractor's point of view. This could be explained by the selection process of subcontractors by the contractor based mainly on the subcontractor's competency. Concerning the affect-based trust and the system-based trust, the scores are quite similar: this reflects that both project's actors founded their trust relationships on the relational investment and the thoughtfulness towards affect-based trust; and on the organizational policy and the company's reputation towards system-based trust in an equivalent way. It is noticeable that from the subcontractor's point of view the H1-statements are scored higher than the H2-statements: this reveals that the subcontractors consider their trust relationships with the contractor stronger than with the other subcontractors. This phenomenon can be explained by the very limited communication among the subcontractors since the communication is mainly centered on the contractor team.
- *Time performance of the project*: the two perceptions on the project time performance are quite similar. It is noticeable that the project time performance score are quite low. According to the project manager, this is due to opportunistic behavior from the subcontractor side to wait as much as possible to be sure to provide works for their entire team. It is also due to delays from the developers towards buyer's choice.
- *Other Factors*: some subcontractors considered the new administrative procedure to declare employee online as a continuous improvement. However, scores of H4 and H5-statements are quite low.

7.6. Case study 6

Description

This project is composed by 187 dwelling in two buildings of 7 floors: one student housing (mainly studios) and the other building is built for a social housing rental company. Three site supervisors work on this project.

The project was delayed due to external factors and it is restrained by the construction of the new roads between the two buildings by another construction company. In addition, the student dormitory has to be completed by the summer to welcome new students for the beginning of the new academic year.

Figure 7-17 Construction site of the case study 6

Main findings from the interviews

- *Contractor:* The project team is newly composed: team members come from different team or are recently hired. Quality issues from the structural works make the planning critical and the works supervisors need to put pressure on the trade works to catch up the completion date. One of the subcontractor company went bankrupt which added time pressure on the contractor and delayed the works of other subcontractors. It decreased the trust relationships among the project actors according to the contractor team. They would like a better working atmosphere concerning planning issues. They mentioned the typical behavior of subcontractor, which consists of waiting as much as possible to start the works to ensure the works flow (collecting apartments ready to be done). They argued that subcontractors only focus on their own interest.
- *Subcontractors:* The subcontractors are not used to work together but knew partly the works supervisors from the contractor company. They have the feeling that they have to endure the problems from the structural works. In addition, some interviewees had concerns regarding the competence of the other subcontractors due to the bankrupt of one of the subcontractors. They mentioned the limited information sharing due to the compartmentalization of the planning discussion. The lack of practicality of planning designed by the contractor without the subcontractor's involvement is decried as well.

Questionnaire results

The questionnaire results for this case study are presented on Figure 7-18 and Figure 7-19 below.

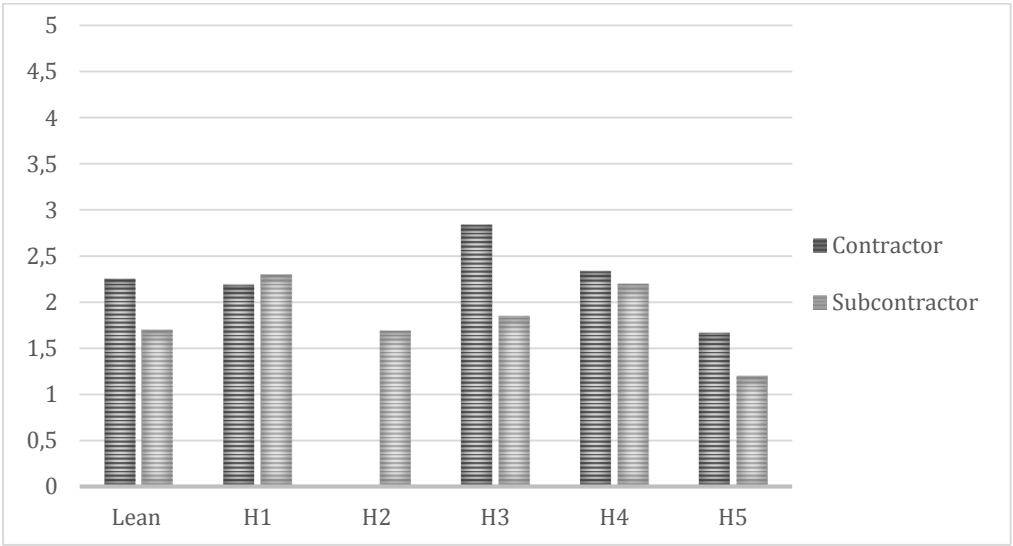

Figure 7-18 Results of the questionnaire for case study 6

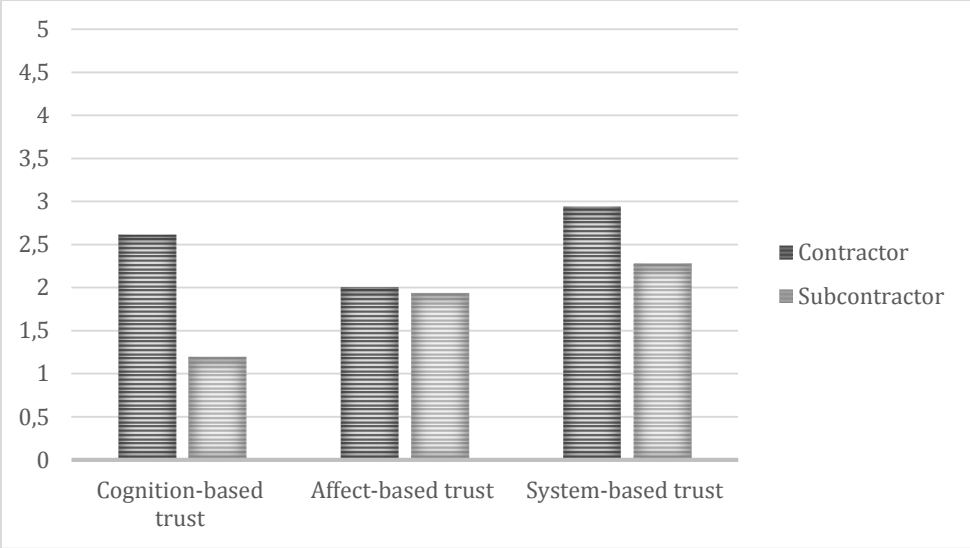

Figure 7-19 Results of the questionnaire regarding trust aspect for case study 6

Results analysis of case study 6

- *Lean implementation*: The degree of implementation of lean tools concerning planning is very low from both points of view which means the lean approach can be considered as non-implemented in this case study.
- *Trust aspect*: The degree of trust between the subcontractors and the contractor (H1-related statements) is quite similar from both sides. Based on the trust distribution scores, there is one major divergence between the two perspectives: cognition-based trust is scored higher from the contractor's point of view. This could be explained by the selection procedure of subcontractors by the contractor based mainly on the subcontractor's competency. Concerning the affect-based trust and the system-based trust, the scores are quite similar. It is noticeable that from the subcontractor's point of view the H1-statements are scored slightly higher than the H2-statements: this means that the subcontractors consider their trust relationship with the contractor stronger than with the other subcontractors. This phenomenon can be explained by the very limited communication among the subcontractors since the communication is mainly centered on the contractor team "compartmented".
- *Time performance of the project*: The contractors scored the project time performance higher than the subcontractors. The relatively low scores seem to be related to the bankruptcy of one of them and to the structural works delays and issues.
- *Other Factors*: The scores of H4 and H5-statements are quite low.

7.7. Case study 7

Description

The project is a nursing home for elderly people who need daily medical care. It is composed by 129 rooms and common services rooms such as kitchen, leisure room, medical rooms, etc. The main characteristic of this project is a mixture between the new building and the old building remaining that is under renovation works.

The critical path concerns the façade due to the difficult access and the complexity to assembly and dismantle scaffolds. The logistic pressure is also an issue in this case study: the available stock areas is very limited and the traffic is very dense around the site.

Figure 7-20 Case study 7 model

Main findings from the interviews

- *Contractor:* The contractor team used to work with the subcontractors and they have planned to keep the same subcontractors for the second phase of the project. The works supervisors paid attention to the logistic aspects especially for the façade subcontractors to smooth the working flow on this critical path. They agreed that the planning is tight and some aspects need to be improved concerning planning issues such as the communication method and the medium term vision.
- *Subcontractors:* The subcontractors used to work together with the works supervisors from the contractor company. They appreciated the work of the contractor on the logistic aspect and consider it as a continuous improvement of the process. They mentioned their willingness to have dedicated meeting concerning planning between the different trades foreman and the works supervisors. They argued that the project is lacking anticipation concerning planning.

Questionnaire results

The questionnaire results for this case study are presented on Figure 7-21 and Figure 7-22 below.

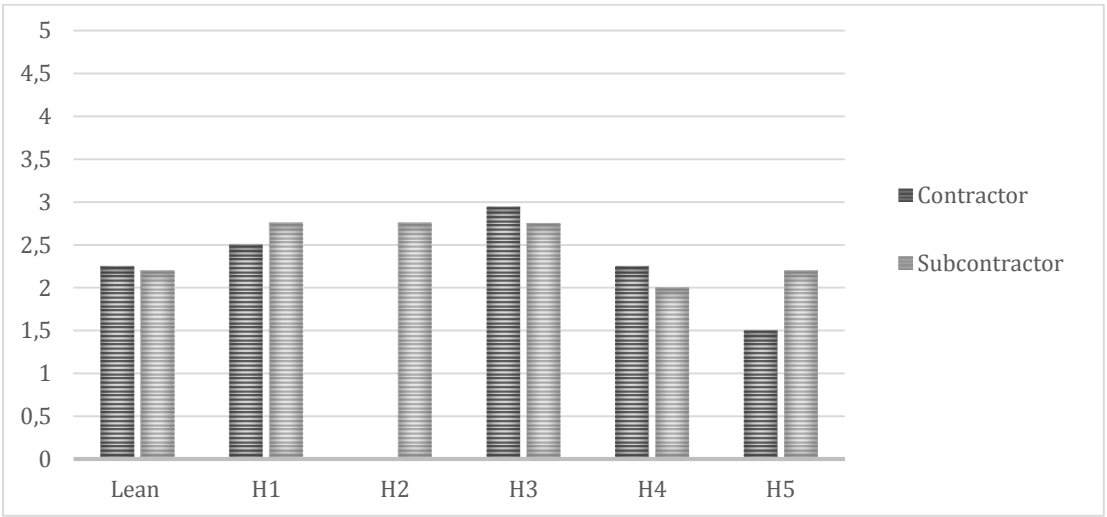

Figure 7-21 Results of the questionnaire for case study 7

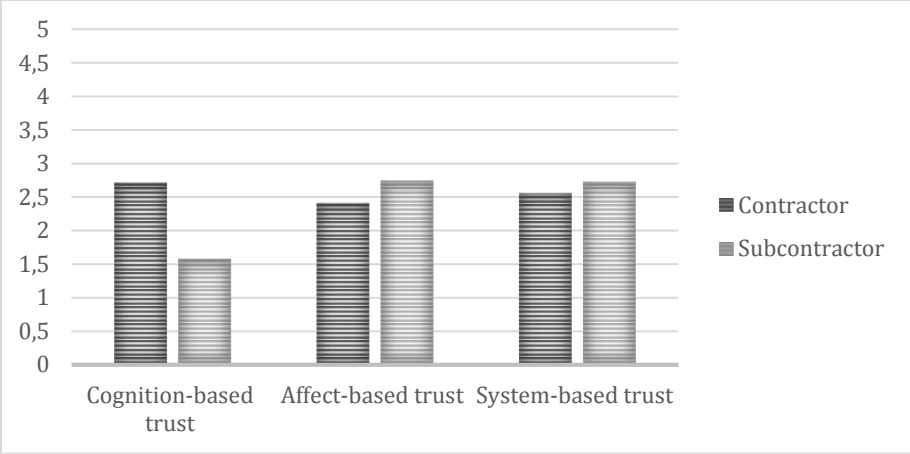

Figure 7-22 Results of the questionnaire regarding trust aspect for case study 7

Results analysis of case study 7

- *Lean implementation*: The degree of implementation of lean tools concerning planning is very similar and quite low from both points of view which means the lean approach can be considered as non-implemented in this case study.
- *Trust aspect*: The degree of trust between the subcontractors and the contractor (H1-related statements) is quite similar from both sides. Based on the trust distribution scores, there is one major divergence between the two perspectives: cognition-based trust is scored higher from the contractor's point of view. This could be explained by the selection process of subcontractors by the contractor based mainly on the subcontractor's competency. Concerning the affect-based trust and the system-based trust, the scores are quite similar. The affect-based trust scores are slightly higher from the subcontractor's perspective. The affect-based trust model is divided into two attributes: being thoughtful and relational investment. Thus, the subcontractors base more their trust considerations on thoughtfulness and relational investment than competency and information flows. It is noticeable that from the subcontractor's point of view the H1-statements and the H2-statements are scored quite the same: this means that the subcontractors consider equivalently their trust relationship with the contractor and with the other subcontractors.
- *Time performance of the project*: the two perceptions on the project time performance are quite similar. The contractors scored it slightly higher than the subcontractors. Those scores are relatively low because the project planning is very tight and the logistic issue does not help to change the story according to the project manager.
- *Other Factors*: some subcontractors considered the logistic effort by the contractor team as a continuous improvement. However, scores of H4 and H5-statements are quite low.

The analysis of each case study provides a lot of information on specific situation. It highlights some trends that need to be compared among these seven cases. The next section will develop a cross cases analysis using the information from the individual cases analysis presented above.

8. Cross cases analysis

The seven cases described in the previous section were initially divided into two samples: the control sample and the research sample. The results of the questionnaire helped to confirm whether or not case studies can be considered as part of those groups. A cross cases analysis will be held within the two groups and then a cross group analysis concludes this section.

8.1. Control sample

The control sample was built on the three projects in which the lean approach was not supposedly implemented. As shown on Figure 8-1, the lean implementation scores lie between 2.25 and 1.7 on a 5-point scale. Subsequently, those three cases are comparable towards the degree of lean implementation and they can be considered as a sample.

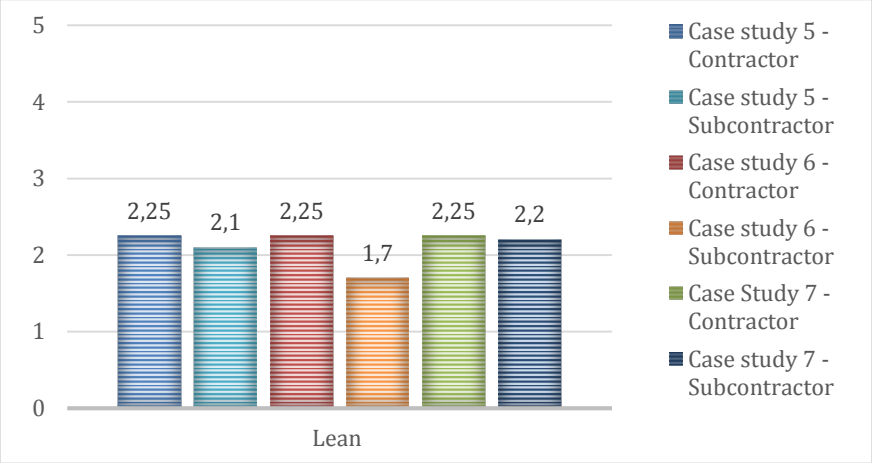

Figure 8-1 Lean implementation scores of the three cases from the control sample

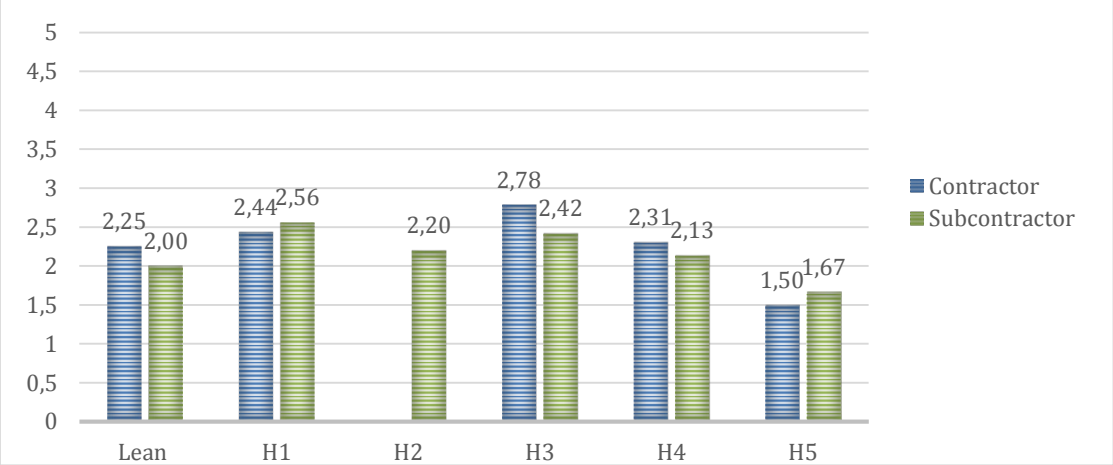

Figure 8-2 Questionnaire results of the control sample

As shown on Figure 8-2, the lean implementation scores are quite low which means that this sample can be considered as a control sample.

The H1-statements scores are quite similar from both points of view and relatively scored in the middle of the scale: approximately 2.5/5. This means that both sides consider their trust relationships equivalently. Based on the trust distribution (shown on the Figure 8-3), the main divergence between the two points of view concerns the cognition-based trust. According to the interviews, this phenomenon can be related to the designation method of the contractor company: the subcontractor selection process applied by the contractor company is mainly based on the competency of the subcontractors. Concerning the affect-based trust and the system-based trust model the scores are quite similar from both sides.

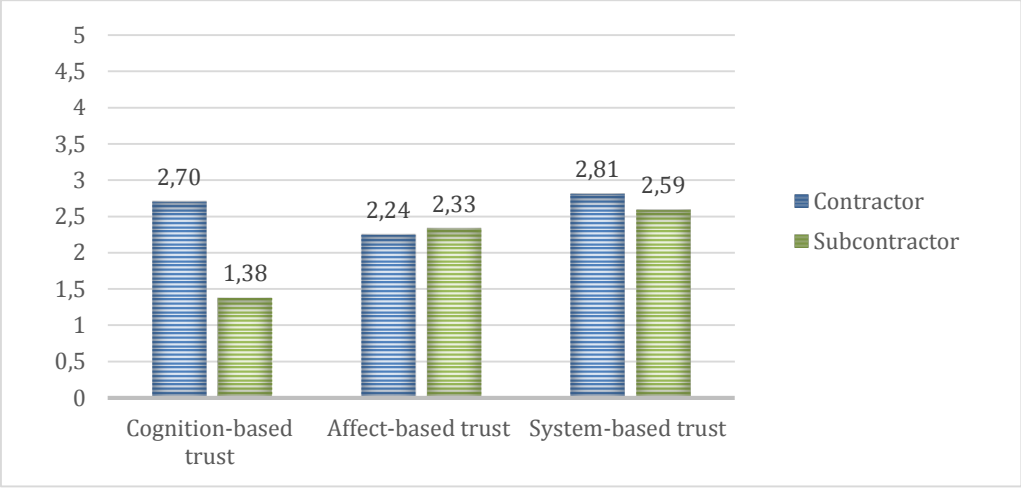

Figure 8-3 Trust Distribution of the control sample

From the subcontractor's point of view, the H2-statements scores are lower than the H1-statement scores: this means that they consider the trust relationships with the contractor stronger than with the other subcontractors. Based on the interviews, this phenomenon can be explained by the communication methods on site concerning planning: the communication is centered on the contractor and compartmented by trades which means that subcontractors have very few opportunities to discuss on planning together.

Project time performance scores are also similar in both visions. It is noticeable that those scores are quite low. From the subcontractors' point of view, this is partly explained by the lack of information concerning the overall project's planning and expected completion date. From the contractor's point of view, those scores result from delays and technical issues such as structural work quality issue or subcontractor's bankruptcy.

Regarding the H4 and H5-statements, the scores are quite low. The reasons behind those scores are very various: new administrative procedure or logistic consideration from the site supervisors for instance.

8.2. Research sample

The research sample is constituted of four cases. As shown on the Figure 8-4, the lean implementation score of those four cases lie from 3.69 to 4.63. The case study 4 could have been excluded from the research sample due to its lower degree of lean implementation. Nevertheless, the difference with the other cases is decent to consider that this case is included in this sample. In addition, the lean implementation scores from the control sample is quite important with the case study 4: concerning the subcontractor, 2 for the control sample score and 3.69 for the case study 4; and concerning the contractor 2.25 for the control sample and 3.92 for the case study 4. For all this reason, the four cases can be considered as the research sample due to their comparable degree of lean implementation.

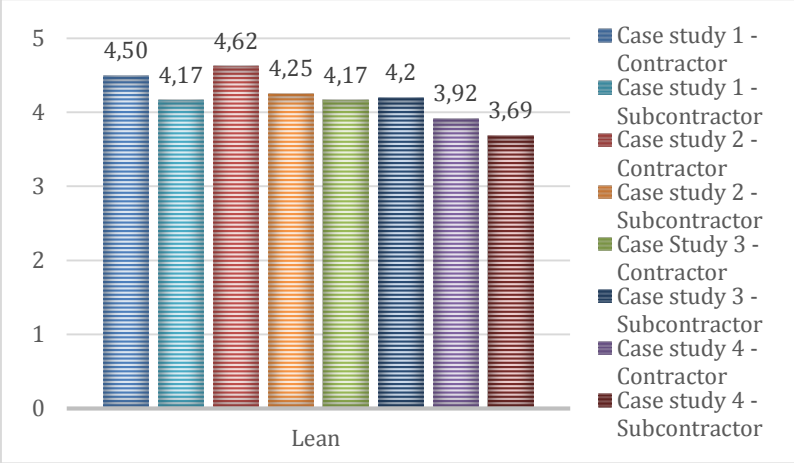

Figure 8-4 Lean implementation score of the four cases from the research sample

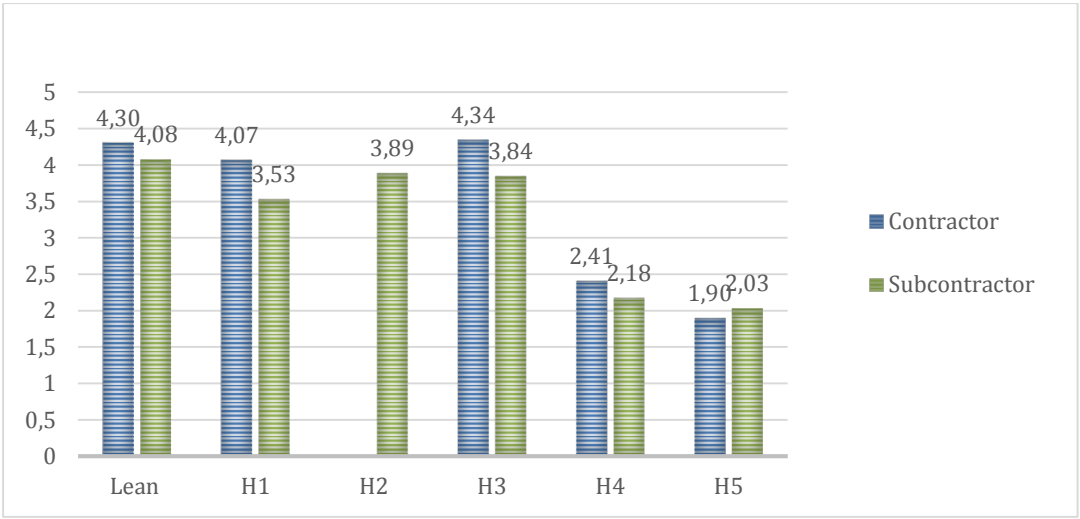

Figure 8-5 Questionnaire results of the research sample

As shown on the Figure 8-5, the lean implementation scores of this group of projects are quite similar from both sides and quite high. This means that this group of projects can be considered as the research sample in comparison with the control sample. The contractor's scores are slightly higher. From the interviews,

this phenomenon could result from the contractor initiative to launch the lean approach on sites.

Concerning H1-statements, scores are comparable between the two points of view and they are quite high. Nevertheless, the contractor scored them slightly higher than the subcontractor. The major reason for this difference from the interviews concerns the selection procedure: the contractor selects the subcontractors and not the other way around, subsequently the contractor orientates his choice to subcontractors with whom he has a better trust relationship.

From the subcontractor's point of view, H2-statements are scored higher than H1-statements: this means that they consider the trust relationship with the other subcontractor stronger than with the contractor. From the trust distribution (shown on Figure 8-6), the divergences concern the three trust models: the contractor's scores are higher than the subcontractor's scores in all trust models. The major difference is in the cognition-based trust: this can be explained by the designation method used by the contractor as explained below. To a lesser extent, the affect-based trust and the system-based trust scores are higher from the contractor's perspective: the main explanation of this phenomenon according to the interviews are the organizational policy built by the contractor company and the fact that the contractors choose the subcontractor with whom they used to work.

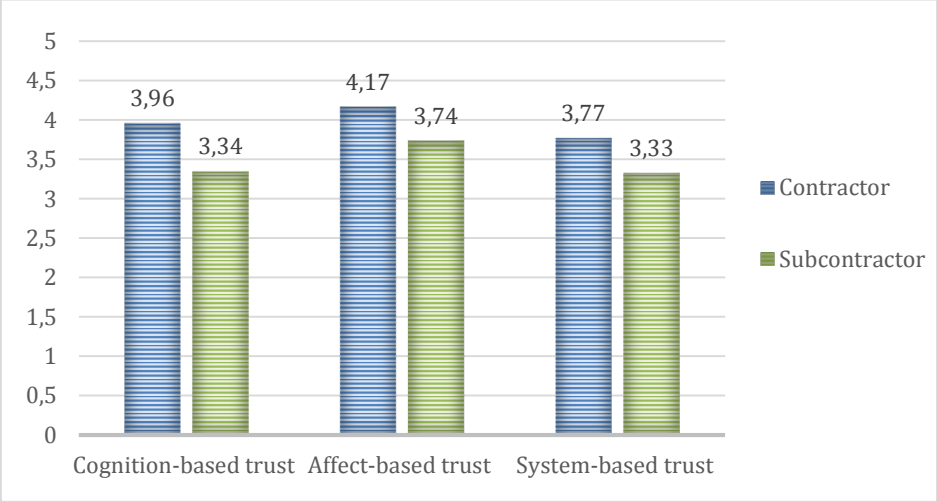

Figure 8-6 Trust distribution of the research sample

Regarding the project time performance, the scores are also comparable from both sides: the contractor's scores are slightly higher than the subcontractor's ones. According to the interviews, the phenomenon results from the lack of solid information about the global project planning provided to the subcontractors. Generally, the contractors generate a "safety" margin as a spare time to ensure the completion date.

The H4 and H5-statements are scored relatively low and are very similar from both points of view. The different arguments from the interviews are quite various: from the new insulation certification to the logistic aspect developed by the contractor team on site.

8.3. Comparison of the two samples

The degree of the lean implementation of the control sample and the research sample are easily differentiated as shown on the Figure 8-7. It is noticeable that the H4 and H5-statements scores are comparable between the two samples. This means that the research sample by comparison of the control sample results will highlight the influence of the lean tools implementation on the project time performance and the trust relationships because the other factors such as external factors are excluded.

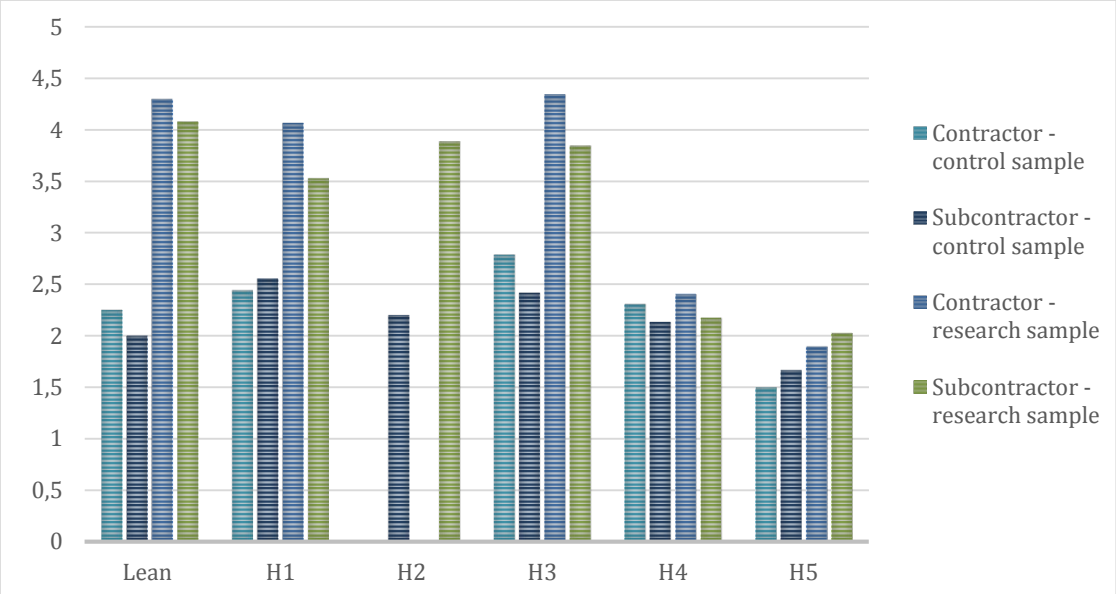

Figure 8-7 Overview of the results of the two sample groups

Regarding the H2, H3 and H4-statement, the scores of the research sample are much higher than the control sample. This global trend reveals the lean tools implementation has positively influenced the trust relationships among project's actors and the project time performance.

Concerning the subcontractor's scores, it is striking to observe a turnaround situation towards H1 and H2-statements: in the control sample the H1-statement scores are higher than the H2-statements scores while it is the other way around for the research sample. This reflects that lean approach had particularly promoted the trust relationships among the subcontractors on site.
Regarding the trust distribution, in both points of view, the three trust models had increased from the control sample to the research sample as shown Figure 8-8 and Figure 8-9.

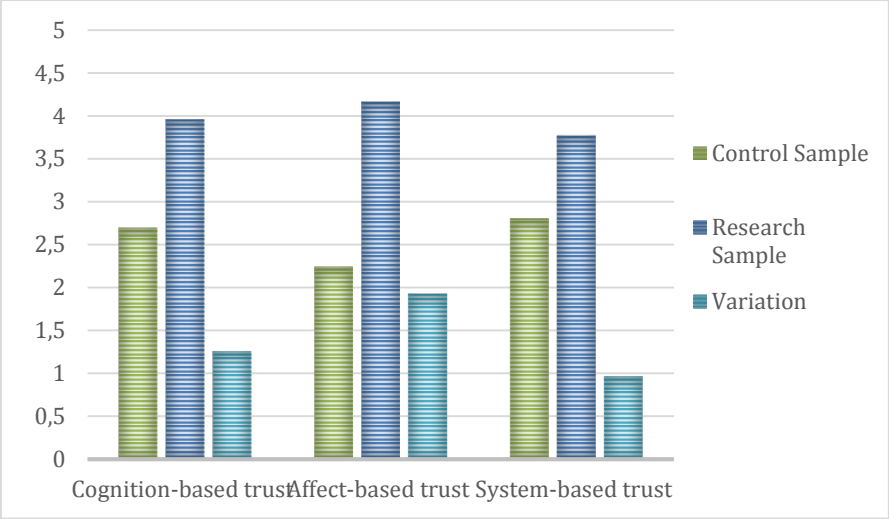

Figure 8-8 Trust distribution from the contractor's point of view

Concerning the trust distribution from the contractor's point of view, the main growth by comparison of the control sample with the research sample concerns the affect based trust and to a lesser extent the cognition-based trust and the system-based trust. In the research sample, the three trust model scores are comparable while in the control sample the affect-based trust much lower than the two other trust models.

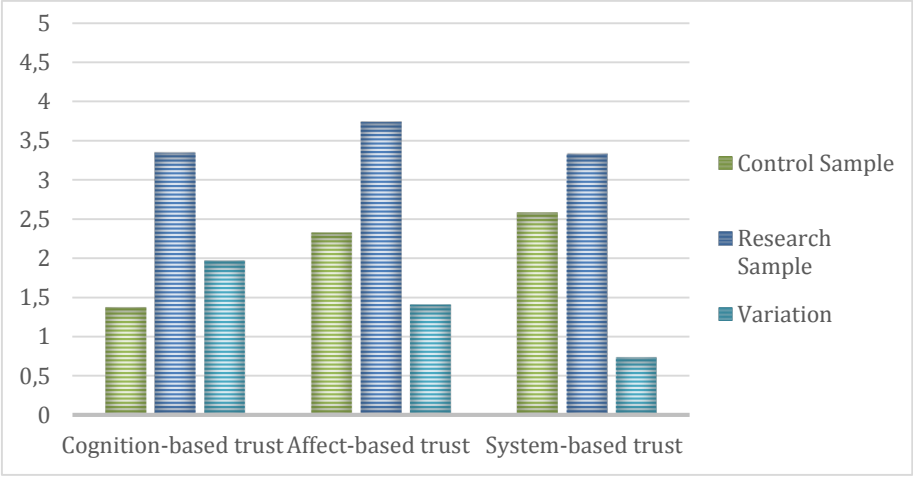

Figure 8-9 Trust distribution from the subcontractor's point of view

According to the subcontractor's results on trust distribution, the most impacted trust model by comparison of the control sample with the research sample is the cognition-based trust. To a lesser extent, the affect-based trust and the system-based trust were positively impacted as well. As noticeable for the contractor's trust distribution result, the scores in the research sample are quite balanced while the cognition-based trust was lower scored in the control sample.

9. Synthesis and validation of the analysis

This chapter provides a synthesis of the analysis in the first section highlighting the main findings which are confronted to the literature and to experts in the second section.

9.1. Synthesis of the analysis

This section summarizes the cross cases analysis of the last section and underlines the link between the analysis and the research sub questions. The analysis process and the main trends highlighted by the cross cases analysis section are shown in Figure 9-1. The first section is dedicated to the identification of the two samples. The exclusion of other routes is explained in the second section. Findings on trust aspect are shown in section three and the results regarding project time performance in section four. The last section focuses on the improvement of the lean process suggested by the interviewees.

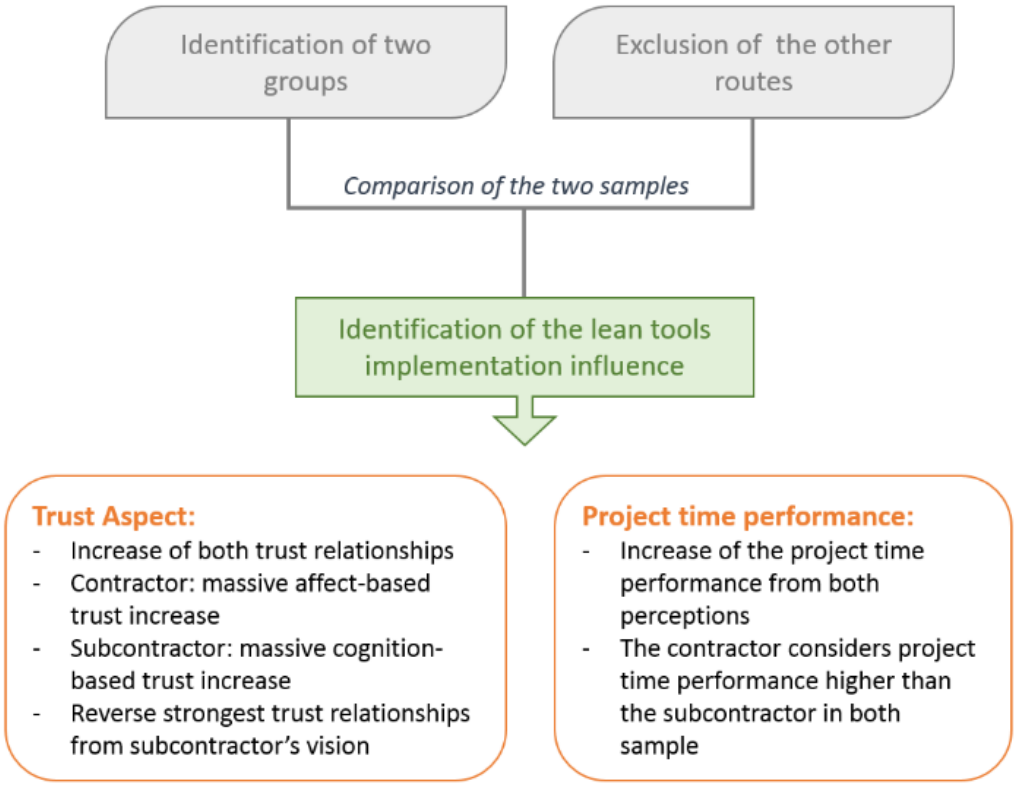

Figure 9-1 Analysis process

9.1.1. Identification of two groups

Firstly, the results of the implementation of lean planning tools allow to identify two groups of projects: one with a high degree of lean planning tool implementation called "research sample" and one with a low degree of lean planning tools implementation called "control sample". Subsequently, in the research sample, the lean tools are perceived as applied by the project's actors. In comparison, they are perceived as non-applied in the projects included in the control sample. As explained in the last chapter, the two groups can be easily identified due to their scores difference shown on Figure 8-7.

The reason to distinguish the two groups is the opportunity to compare their results. Since the major difference between the two samples is the lean approach, the comparison leads to the highlighting of lean influence on the findings. However, in order to clearly identify the influence of lean planning tools, it is necessary to consider different routes from the implementation of lean planning tools to the project time performance.

9.1.2. Exclusion of other routes

Besides the implementation of lean planning tools, the two samples have the same project background: same contractual procedure, same area, similar projects, etc. To ensure that the findings were not impacted by other factors than lean tools implementation through the trust aspect among the project's actors, the continuous improvements and the direct connection between lean tools and project time performance were assessed respectively by the H5 and H4-statements. From the last section, it is noticeable that the H5 and H4-statements scores are very similar between the two groups of projects as shown on Figure 8-7. This means that the external factors and continuous improvement can be excluded in the comparison between the two samples. Thus, the influence of lean tools through the trust aspect can be clearly identified by comparing those two samples.

9.1.3. Trust aspect

The last two sections allow the identification of the lean planning influence on trust and provide an answer to the second research sub question.

> ***How does the implementation of the lean planning tools influence the trust relationships between the contractor and the subcontractors and among the subcontractors?***

Comparing the two samples, both trust relationships between the contractor and the subcontractors and among the subcontractors had increased due to the lean tools influence. However, the lean approach had impacted differently the two types of actors: the most influenced trust model from the contractor's point of view is the affect-based trust model, and from the subcontractor's point of view it is the cognition-based trust model. This phenomenon results from the shift from a

communication centered on the contractor to a more distributed communication method. The implementation of lean tools promotes particularly communication between the subcontractors which leads to more information sharing especially on technical issues impacting the planning; and the improvement of problem solving process. Moreover, the phenomenon is also due to the contractor's designation process concerning the subcontractors mainly based on the subcontractor's competency: the cognition-based trust from the contractor is not problematic from the contractor point of view.

In addition, the subcontractors have switched their strongest trust relationship from the contractor to the other subcontractors with the influence of the lean approach. This reflects that lean tools influence predominantly the relationship among the subcontractors which is mainly related to the promotion of the communication between the subcontractors due to the implementation of lean tools.

9.1.4. Project time performance

In the same way, the identification of the two samples and the exclusion of other routes provide input to answer to the last research sub question on the project time performance.

> ***What is the impact of trust aspect on project time performance?***

By comparing the two samples, the trust aspect has positively impacted the project time performance from the contractor's and the subcontractor's point of views.

It is noticeable that the contractor's scores are in both samples higher than the subcontractors' scores. This phenomenon was explained by the "safety" margin created by the contractor towards the subcontractors. This leads to different perceptions of the project time performance: the subcontractors have an earlier completion date than the contractor.

In addition, it is noticeable that the direct relation between the implementation of lean tools and the project time performance is quite low even in the research sample in which the lean tools are implemented. This means that the deterministic factor influencing the project time performance seems to be the trust aspect.

9.1.5. Suggested improvements

Throughout the interviews in the seven projects, the potential improvements of the planning process were asked to interviewees. From their answers, three main improvements were identified.

Firstly, the integration of the logistic approach in the lean planning tools was the most redundant advised progress. Two projects had developed in parallel logistic considerations to cope with very limited stocking area on site. Both

perspectives (subcontractors and contractor) agreed on the importance of logistics in construction projects.

The second suggested improvement concerns the simplification of the lean approach. This can be done in various ways: dividing the project into smaller groups of subcontractors to reduce the duration of the planning meetings, considering the buildings by floors rather than by apartment concerning the planning or simplify the planning process if possible. Each project found its own way to adapt the tools to meet its needs on site. The main goals to the simplification of the approach are (1) increase the number of participants, (2) increase the anticipation of problem and mistake on site by promoting communication.

The last proposed improvement comes from the first case study: they would like to involve more widely the other project's actors such as project developers, buyer and architects. Indeed, the planning is not only between the contractor and the subcontractors: the developers and the buyers are sometimes the blocking elements by not sharing information such as buyer's choice on paintings or on tiling for instance. To go a step further in this philosophy, the integration of the planning lean approach in the contracts not only with the subcontractors but also with the project developers and architects, can be considered in the future.

9.2. Validation of the results

This section confronts the findings from the case study analysis to the experts' opinions from the construction industry and to the expected results from the literature. The first section presents the interviews of experts, mainly composed by project managers from the contractor company. The second section of this chapter is focused on similar findings from the literature and compares them with the results of the analysis.

9.2.1. Expert's interviews

In order to validate the results, they had been confronted to respective case's project managers. Globally, they support the results of the questionnaire by providing an explanation of the highlighted trends. The interviews' scripts and transcripts are shown in appendix 4. They identified the main influencing factors towards the relationships between the contractor and the subcontractors and among the subcontractors that need to be taken into account to understand the findings: (1) the difference of nature: contractual bindings between the contractor and the subcontractors which does not generally exist among the subcontractors and (2) the standardized designation process from the contractor company: it is based on the subcontractor's price offer, their competency and from their grades on the contractor's data base. Indeed, at the end of construction project, the site supervisors grade their subcontractors to help other contractor's team to select their subcontractors. Another factor was dismissed by the project's managers: the

influence of the head office on the perception of lean tools implementation. The lean construction is the new trendy approach launched by the head office on all their building site. Thus, a pressure could have been felt by the site supervisors to overestimate the questionnaire's scores but the project's managers rejected this explanation.

The main consultant had also been interviewed to comment the results and give his opinion. He agreed on the main trends and completed the project manager's explanation by providing a more global insight on the case studies. From his external point of view, he mentioned that the influence of the contractor company's head quarter on the results especially the scores concerning the degree of lean implementation and the project time performance is probably underestimated by the contractor. According to him the pressure form the head quarter to implement lean planning had an impact on the results about the degree of lean implementation. Nevertheless, his point of view is not objective and can be biased as a consultant, his job is to help the company to implement the lean tools.

9.2.2. Similar findings from the literature

Literature on the association of the trust aspects between the subcontractors and the contractor with the influence of lean tools implementation on the project time performance is very scarce. Indeed, the scientific papers and books are either focused on the relation between the lean tools implementation and the project performance or focused on the impact of trust relationships on the project's performance. This section confronts the findings from the analysis to the expected results based on the literature.

Concerning the influence of trust

Wong studied trust influence in construction project in Asia in different papers based on various trust models considering the relationships between the client and the contractor. Wong and Cheung (2004) studied the trust aspect between the contractor, the client and consultants in construction projects based on Hartman's trust models: they found out that the system-based trust were very influencing from both sides to enhance the trust cycle. They have noticed that the contractor groups put a great importance on the permeability and the performance on the counter part as well. To validate their results they have interviewed industry experts. Besides, the scope of the research is slightly different from our project research, these results seem in line with the questionnaire findings concerning the contractor's point of view: cognition-based trust, which is partly based on the competency of parties, is scored quite high from the contractor's point of view and is the major influenced trust model from the subcontractor's point of view. Wong (2008) also studied the trust relation between the contractor and the client in construction project based on the similar trust models as our research project. The cognition-based trust was the highest path to build trust relationships, followed by the system based trust. Besides the scope of those two studies is not similar to the thesis project - the lean tools implementation is supposedly not included and the subcontractors are not taken into account in the Wong's works -, the general trends

on trust aspect are quite comparable: the cognition-based trust model is found to be the influencing factor to build trust.

Laan, Voordijk, and Dewulf (2011) had studied trust building between the client and the contractor: they highlighted that two main factors influence the trust mechanism: transparency and co-location working environment. They found out that the inter-personal trust is constitutive to the inter-organizational trust. To make the link with our research framework, the transparency is included in the cognition-based trust model in the information flow attribute. However, the co-location working environment were not taken into account in our research project because it is always the case in the seven studied projects. In the same way, Macomber and Howell (2003) consider the trust between coworkers as a significant issues to the overall functioning of projects. This phenomenon is highlighted in the findings of Laan et al. (2011) as well.

Koskenvesa and Koskela (2012) had identified the importance of trust to implement lean planning tools to allow people to talk about problems and mistakes 'out loud'. They pointed out the contractual binds which restrain collaboration among project's actors: "contracts and clauses become sand in the wheels of collaboration". The relational trust seems to be neglected by the construction industry in comparison with the strong stress on the institutional-based trust. It is noticeable that the findings of Koskenvesa and Koskela on lessons learnt present some similarities with the improvements described in the last section of the thesis: regarding the contractual aspect and regarding the difficulties in revealing problems.

In most of the articles, the scope of the research is not the same. Relationships between client and contractors had been much more studied than between the subcontractor and the contractor. In addition, lean tools are not taken into account either. However, the trends concerning trust aspect in construction projects are quite similar to the findings from the analysis.

Concerning the lean tools influence on project performance

Salem et al. (2006) studied the last planner system in construction projects decomposing it into four elements: (1) reverse phase scheduling; (2) six weeks look ahead; (3) weekly work plan; (4) analysis of the reasons for variance; (5) PPC chart. They found out that the last planner is ready to be implemented into construction projects with more emphasis on the analysis of the reasons for variance. They also mentioned the possibility to simplify the tool by reducing the frequency of meetings or create smaller groups of concerned people. Those remarks came up during the interviews as well.

Koskela and Howell (2002) summarized industrial experiments in which the introduction of Last Planner leads to clear benefits: a productivity increase of 10 % was reported in Denmark and Ballard (2000) has measured productivity increases from 10 % to 40 %.

Despite only the perception of the project time performance was measured in this project research, the trends are the same. However, it is noticeable that in the literature most of the projects' performance towards lean tool implementation is assessed through the percentage of plan completed (PPC). In this research

project, this indicator was not applied in all the cases studies. Subsequently, it was not possible to compare the findings based on this indicator.

Since the literature with a similar research scope is relatively limited, the confrontation of the cases' results to the theory becomes complex. Nevertheless, the findings from the analysis part are in line with the literature concerning the trust aspect in the construction project on one hand and concerning the lean tools influence on the other hand.

This chapter presented the analysis of the research project. Each case was briefly presented and its results were analyzed based on interviews' remarks. Then, two samples had been identified according to the degree of lean tools' implementation. Each sample's results had been analyzed and the main trends were explained based on the case studies analysis. The comparison of the samples leads to the synthesis of the analysis presented in the section four of this chapter. To ensure the findings of the analysis, the results had been confronted to experts of the construction industry and the expected results from the literature in the fifth section. The next chapter will draw a global conclusion of the research project by answering the research question and by providing recommendations and reflections.

Part Three: Conclusions

"To be human is to be the kind of being that generates commitments, through speaking and listening. Without our ability to create and accept (or decline) commitments we are acting in a less than fully human way"

Winograd and Flores, 1987

This last chapter draws the conclusion of the complete research project and achieves this thesis report. It gathers inputs from the previous chapters to answer the research question, provides recommendations and reflects on the research project.

The first section provides the answer of the research question based on the synthesis of the analysis from the last chapter. Recommendations for the construction companies on one hand and to the scientific research on the other hand will be provided in the second section. The last part on this chapter is focused on reflection on the research project highlighting limitations and further research orientation.

10. Final conclusion

The research project came from the construction company's needs to reduce wastes concerning planning issues on construction site. Indeed, Bouygues Batiment found out that the trade works planning was particularly problematical. They identified room for improvement concerning the planning during this phase of the works especially regarding the trust relationships among the project's actors. This was the foundation of the scope of the research.

The research problem was translated into research question, research sub questions and research objectives presented in the first part of the report based on the theory developed in the scientific literature. The literature review provides a theoretical pattern to the research project towards lean tools and towards trust aspect in construction projects. The theoretical framework has been operationalized in the research strategy and methodology sections.

The second part of the report was focused on the analysis: first presenting the case studies analysis, secondly by analyzing the two identified samples. The comparison of the control sample with the research sample leads to the synthesis of the analysis. The part two of the report ends with the validation of the findings through expert interviews and confrontation with the expected results from the literature.

The results of the analysis and the research sub question provide inputs to answer the main research question of the thesis.

> ***To what extent does the implementation of Lean planning tools influence time performance of building projects through the improvement of trust relationships?***

Hypothesis 1 and hypothesis 2

The research highlights the influence of lean tools implementation on trust relationships between the contractor and the subcontractors and among the subcontractors. The analysis identified that the two project's actors are not impacted in the same way by the implementation of lean tools: from the contractor's point of view, the affect-based trust model presents the most significant increase while it is the cognition-based trust from the perspective of the subcontractors. This phenomenon can be explained by two main reasons: (1) the contractor's designation process mainly founded in the competency of subcontractors and by (2) the communication shift from a centered communication of the contractor to a more distributed communication among the project's actors and especially the subcontractors.

Hypothesis 3

The results also highlight the impact of trust relationships on the time performance of the project. From both sides, the time performance of the project was perceived as increased. It is noticeable that the contractor scored it higher than the subcontractors. This phenomenon was explained by the "safety" margin created by the contractor to ensure the completion date. Subsequently, the subcontractors did not always have the same datum as the contractor.

Hypothesis 4 and hypothesis 5

Nevertheless, the relation between the trust aspect and the time project performance was particularly significant since the direct relation between the implementation of the lean tools and the project time performance is marginal. Indeed, the hypotheses related to the influence of external factors between the implementation of lean tools and the project time performance and related to the direct connection between the two were scored very similarly in both samples. This means that the influencing factor on the project time performance is the trust aspect rather than the lean tools, in other words lean tools "only" promote trust aspect and have a limited influence of the time performance of the project directly. This leads to the reflection on the possibility to find another tools that promote trust aspect besides lean tools.

The Figure 10-1 gives an overview of the findings exposed above regarding the five research hypotheses.

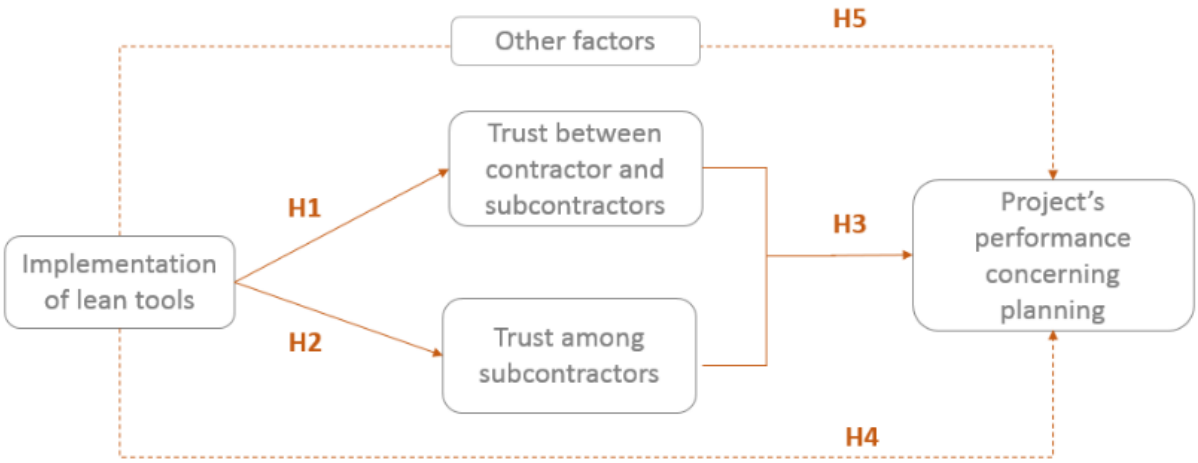

Figure 10-1 Overview of results on the research hypotheses

11. Recommendations

In the previous sections, various sources of improvement of project's performance and development of trust concerning planning were identified. The first section presents recommendations for the construction companies and the second section is orientated towards further research on the topic.

11.1. Recommendations for the construction companies

Since the lean construction is quite new for the French construction industry, this section will provide some recommendations to enhance the project performance regarding planning and then larger scale to improve the implementation of lean approach on construction site.

Importance of trust aspect regarding the project time performance

From the findings, the trust aspect appeared to be essential concerning the project's planning. Subsequently, the main recommendation to the construction companies is to promote trust relationships among the different project's actors and particularly among the subcontractors and between the contractor and the subcontractors. This aspect is sometimes underestimated on site and lean tools regarding planning seem to be relevant tools to enhance the trust cycle. It is noticeable that the designation process plays an important role regarding the trust aspect between the contractor and the subcontractors.

Improvement of lean approach

Three improvements of the implemented lean approach have been identified during the analysis: (1) integration of the logistic aspect in the lean planning process; (2) simplification of the lean tools implementation; and (3) involvement of more project's actor from the design phase of the project to the execution phase.

Indeed, the logistic issues have a major impact on the project's planning. The integration of this aspect into the planning process helped to ensure the schedule and reduced conflicts among the projects actors. Several methods can be developed to anticipate logistics issues for instance by managing the stocking areas and the transportation means in an efficient way. From the case's findings, logistic tools are underused in the construction industry in comparison with the other industry. In other words, there is room for improvement towards logistic aspect.

The implementation of lean tools towards planning aspect is sometimes restrained by its complexity. Indeed, if the tools need more effort than the added value brought by the tools, there would be no point to use it. Some suggested improvement were given by the analysis: (1) reducing the duration of the planning meeting by dividing the subcontractors into subgroups with high degree of interaction; and (2) reducing the scope of the lean tools: reducing the concerned area or reducing the projection to fewer weeks. Those solutions are not perfect-

less information, less communication - but they can avoid the failure of the lean approach and keep the collaborative aspect regarding planning.

The more widely involvement of project actors concern not only the construction industry but also the scientific community. In the seven studied cases, it was found that other actors than the subcontractor and the contractor were involved in the planning issues such as the urban developers, the client, the architect or the municipality for instance. Involving more people increases the capacity to anticipate planning issues and improve the problem solving process. Besides the planning aspect, involving more stakeholder contributes to the communication on the project. For all those reason, it could be interesting for the construction companies to develop more widely then involvement of stakeholder into the planning process and more specifically into the lean approach.

The implementation of lean planning tools in construction site was very focused on the techniques: the contractor team was not much aware of the lean planning mechanism and especially concerning the psychological aspect of the approach. Indeed, the results from the research highlight the importance of the trust influence on the project time performance in comparison with the lean planning influence.

The lean construction has recently started to be implemented on construction project in France. Thus the French construction industry needs time to develop and improve the techniques. The recommendations above are designed to help this development in the future.

11.2. Recommendations for further research

The research analysis and conclusion highlight some relevant topics to investigate more deeply for further research. It the case of external factor and the consideration of alternative tool to improve trust aspect.

Consideration of the external factor

The results of the analysis highlight very diverse external factors influencing the results: new administrative procedure, logistic issues, certification, etc. The logistic aspect was a redundant suggested improvement from the interviews in both samples. In the same way, the administrative procedure can have a direct impact on the trust aspect among the project's actors and the project time performance. Thus, it could be relevant to study more the external factors influencing the project's planning and trust aspect regarding lean tools.

Alternative tool

As mentioned in the first section of his chapter, the results from the analysis highlighted the strong relation between the trust aspect and the project time performance and a relatively weak direct relation between the implementation of lean tools and the project time performance. This means that the trust aspect is essential to increase the performance of the project concerning planning. This leads to a reflection on the possibility to find another relevant tool that promotes the

trust aspect beside lean tools. The Figure 11-1 shows the integration of this alternative tools into the research design of the thesis.

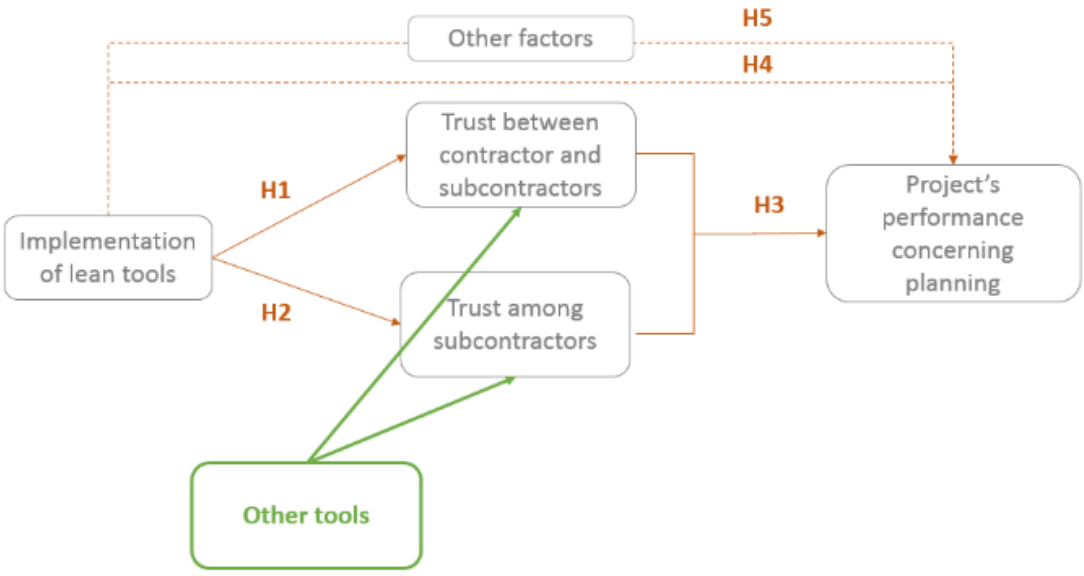

Figure 11-1 Overview of the alternative tools influence

Alternative tool to promote trust building are diverse in the literature. Vangen and Huxham (2003) identified two main aspects to initiate the trust-building loop: (1) forming expectation by identifying partner and agreeing on collaboration aims and; (2) managing risk. Indeed, they linked trust aspects to risk. They have also defined three actions to sustain the Trust-Building loop: (1) managing dynamics; (2) managing power imbalance; (3) nurturing the collaborative relationship. However, the trust building strategy depends on the trust management. This distinction is highlighted in Figure 11-2 below.

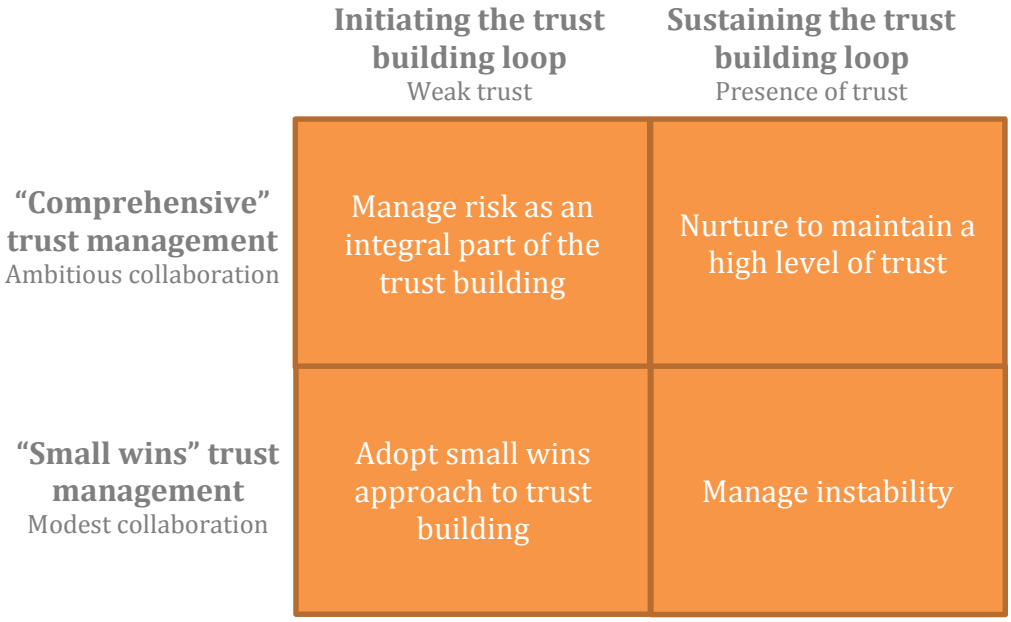

Figure 11-2 Managing trust according to Vangen and Huxham (2003)

Vangen and Huxham (2003) explained how to manage trust in the four cases shown on the table above.

- *Managing the risk as an integral part of trust building*
  This consists of assessing potential for achieving collaborative advantage and for determining how the associated risks can be managed and whether it worth taking. This is possible by exploring the complexity of structure: determination of the power network, stakeholder analysis, negotiating agreement, etc.
- *Nurture to maintain a high level of trust*
  The main objective is to facilitate trust building by keeping nurturing relationships, promoting communication and credit recognition, etc., to create a basis for collaborative advantage.
- *Adopt small wins approach to trust building*
  This aims at initiating trust by getting stated without having to deal with all aspects of trust building. The first step is to identify relevant partners with whom to build trust to start undertake joint actions.
- *Manage instability*
  In this scenario, the main objective is to sustain trust long enough to reach a decent level of trust by managing the dynamics and power imbalance.

The psychological safety promotes collaborative behaviours in groups and institutions: making people "feeling safe to speak up, ask for help and provide feedbacks" (Edmondson & Lei, 2014). Similarly to Vangen and Huxham's theory, Edmondson and Lei (2014) found that collaboration needs risk consideration and management: "the manager must create a climate of psychological safety to mitigate interpersonal risks and make collaboration more likely, particularly in face of uncertainty, complexity and interdependence".

Laan et al. (2011) who highlighted that higher level of trust lead to better project outcomes, mentioned two aspects which promote trust virtuous circle: (1) transparency and (2) co-location at work. They also mentioned that organizations play an important role into the trust building process by adopting an attitude reflecting benevolence and dedication to face problem.

Bercovitz et al (2006) and Kumar et al. (1998) described different trust building mechanisms. Kumar et al. identified that trust building is highly dependent on the environment changes and grand strategy of partner.

Further research on alternative tool influencing the trust relationship among the project's actors to study its influence on the project time performance will allow to (1) assess the results of this research concerning the trust aspect and (2) develop efficient tools concerning the planning in construction project.

12. Reflections

This section presents the reflection on the research project: first by highlighting the limitation of the research strategy and in the second part by considering of the implementation of lean planning tools. The last section gives a discussion beyond lean planning.

12.1. Limitations of the research strategy

The research strategy reaches limits that need to be taken into account to fully understand the results of the research project.

Subjective assessment

The subjectivity concerns two aspects in the research strategy: firstly the assessment of the hypotheses by the interviewees based on perception and secondly from my position in the company during the research project.

The assessment of the research hypotheses by the interviewees through the questionnaire is very subjective. In other words, in the same situation, same project, same company (either contractor or subcontractor), two different persons could have scored differently the research hypotheses because they perceived the situation differently. The most striking example of this characteristic of the research design concerns the time performance of the project: time performance could have been assessed more objectively: for instance comparing the initial planning completion date with the execution completion date. The choice of subjectivity was chosen in this research project to fit with the trust aspect and make the differences between the two points of view to be able to compare them.

In the same way, the subjectivity also concerns the "researcher" side. Since I worked for the head office of the contractor company to deploy the lean approach on construction site, I might have a biased point of view despite I made effort to be as neutral as possible. This remarks can also be applied concerning the answer I got from the interviewees knowing my work position. I did my best to avoid those mechanisms, but I am aware that this situation can have an impact on the findings.

Limited literature on the scope of the research

The literature dealing with the influence of lean tools on project time performance through trust aspect is very scarce. Indeed, most of the concerned literature is focused either on the impact of lean tools on project performance or on the impact of trust aspect on project time performance. This scarcity makes comparison of findings limited and it restrains the validation of the results by confrontation with the expected results from the theory.

Identified external factors

From the analysis, two main factors that impact trust relationships between the contractor and the subcontractors and among the subcontractors were identified: (1) the difference of relationships nature: contractual between the contractor and subcontractor on one hand; and non-contractual among the subcontractor on the other hand; (2) the standardized designation process mainly based on the

subcontractor's competency and the price: thus the cognition-based trust model is ensured by this procedure.

In addition, as explained in the last section other non-identified external factors might have oriented the results as well: investigation towards this direction might be interesting for further research.

Distribution imbalance of the hypotheses in the data collection process

In the questionnaire statements exposed in the methodology section, the first three hypotheses (H1, H2 and H3) are overrepresented in comparison with the hypotheses four and five. This numerical effect in the data collection process could have an impact on the research findings despite the results are based on weighted average depending of the number of related statements in the questionnaire. Indeed, the respondents did not have the same opportunity to express their opinion on the five hypotheses. Thus it is interesting to consider this aspect as a research limitation which can be studied in further research.

12.2. Implementation of the lean planning tools

The degree of implementation of lean tools had been assessed during the interviews. This evaluation is only quantitative but this does not provide any information on the manner the lean tools were implemented in the different cases. The planning tools might not have been applied correctly or applied only partially. Indeed, based on the literature review, the last planner system requires several steps to be fully implemented (Zimina and Pasquire, 2012; Koskenvesa and Koskela, 2012; Ballard et al., 2002). The choice to set aside the quality of lean tools implementation had been made to reduce the complexity of the research. However, it is important to reflect on this aspect in order to take it into account to understand the findings and to orientate further research as well.

12.3. Beyond lean planning

The first intention of this research project was to study the planning lean tool and its influence on trust aspect and time performance in construction projects. But the results of the research turn out to be different: they have highlighted that the lean planning tool was not the deterministic variable towards project performance since the relation between trust and time performance is stronger than the direct relation between lean planning tool and project time performance. Indeed, this means that other alternative tools promoting trust among the project's actors could have the same impact on the project time performance. At first sight, this was quite disturbing because lean planning was the topic of the master thesis but these findings raise new interesting opportunities for further research on planning tools besides lean planning.

List of abbreviations

ADM: Activity Definition Model

BIM: Building Information Modeling

BY: Bouygues, considered as the contractor in this report

ENR: Engineering new-record

IGLC: International Group for Lean Construction

INSEE: National Institute Statistics and Economic Studies - France

LC: Lean Construction

LM: Lean Management

LPS: Last Planner System

PM: Project Management

PPC: Percentage of promised (planned) complete

ST: Sous-traitant = subcontractor in French

WWP: Weekly work planning meeting

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Appendices

Appendix 1: *The description of the planning lean approach during the trade works in the construction company*

The case studies context of the planning strategy and the context of the lean approach within the contractor's company are essential to understand the implementation of the lean tools. This section gives a brief overview of the company planning strategy and the lean approach.

1. The planning strategy of the company

The planning process is based on the principle that the precision of the planning becomes higher with the progress of the projects. During the procurement phase, the planning is composed by a basic Gantt chart. It is detailed and staged in the design phase based on the physical characteristic of the building. Then during the execution phase the planning includes location of activities. The project team is free to choose the planning they are comfortable with.

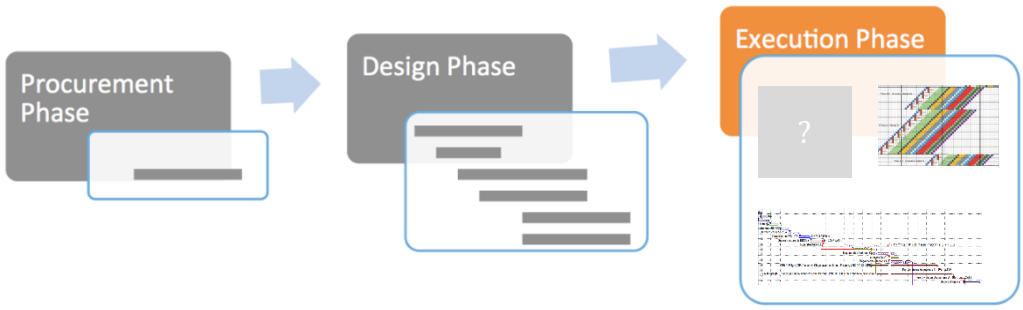

Figure A - Planning process

2. The Lean approach in the company concerning trade works planning

The lean approach is implemented between the design phase and the execution phase and during the execution phase. The project team members are helped by a consultancy company to support the approach. The consultant are present on site a dozen days per project on average to start the approach and to coach the team during the project progress. The site organization is summarized on Figure B. Contractor team members participate to a one day workshop before the beginning of the project to acquire the methodology and to train on simple case studies with the consultant.

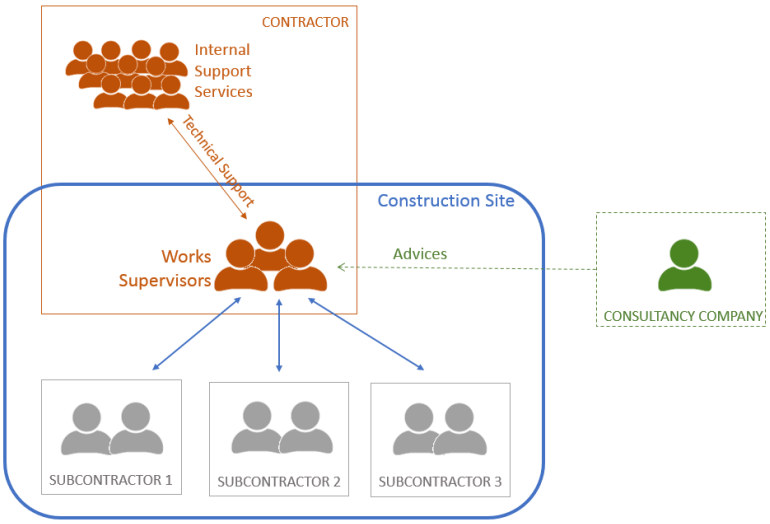

Figure B - Overview of the typical site organization

Main differences between the traditional and the lean approach

The main differences between the traditional approach and the lean approach concern the collaborative aspect of the planning and the visual interpretation of the planning. The contractor wants to avoid conflicting situation with inefficient communication among actors and especially between the contractors and the subcontractors.

Lean Approach	Traditional approach
Collaborative planning preparation	Contractual and imposed planning preparation
Targeted and transverse communication (mainly face to face)	Centralized communication (mainly by phone and email)
Constructive interactions between actors in case of difficulties: shared problem solving process	Conflicting interactions between actors in case of difficulties : procedural problem solving process
Mutual commitment	Protection of its own interest
Buffer pooling	Individuals room to ensure own interests

Table A - Main identified differences of the lean approach and the traditional approach within the company (based on Bouygues internal documents)

Lean approach

The lean approach is mainly based on the LPS theory developed by Ballard (1997). The implemented approach concerning the trade works planning is composed by five steps described in the Table B. The last column shows the contributor(s) of each steps.

	Design planning	This planning gives a global vision of the different trade works	Contractor
	Phased planning	This planning is the decomposition of the design planning into phases based on the technical constraints	Contractor

	Collaborative planning validation	This planning is a detailed work plan with precision on the sequences, the potential constraints to start the works, etc	Contractor + subcontractors
	Collaborative weekly planning	This is a weekly work planning on three weeks in which the subcontractors and the contractors assume responsibilities.	Contractor + subcontractors
	Feedback indicators	From the indicators, the progress of the project is collected and non-completion reasons are studied	Contractor (+ subcontractors)

Table B -Trade Works planning process in the lean approach of the company (based on Bouygues internal documents)

The two first steps of the lean approach consist of a Gantt chart: the design planning is a basic Gantt chart with the main activities. The phased planning is drawn during the foundation of the building and includes technical factors such as the dismantling of the crane, start of the lift, waterproofing protection, etc. Based on this data, the general phasing is included in the planning. Figure C and Figure D show overview of those planning.

Figure C - Overview of the design planning: Gantt chart

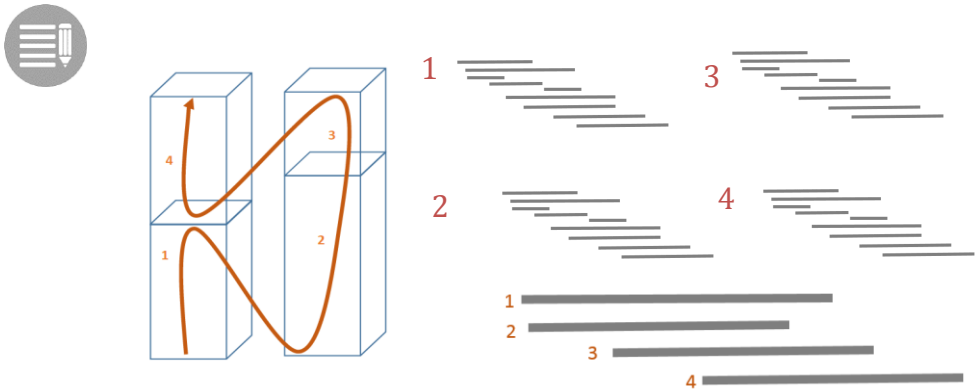

Figure D - Overview of the phased planning: phased Gantt chart

The third step consists of ensuring the phased planning and includes the location aspect of the activities. Subcontractors are involved in this stage to confirm the working process and highlight potential interactions that need to be taken into account. The time-location planning is a possible deliverable of this stage as shown on
Figure E.

The benefits of the time-location planning are (1) global vision of the planning; (2) the different subcontractors can see clearly where and when their activities are planned by following their color; (3) the main contractor can check the progress of work. However, this schedule is not flexible for daily works. For this reason, it is necessary to implement another tool for a more precise supervision. This schedule helps to improve the communication between the contractor and the subcontractors. The color does not need translation to be understood and are visually easy to follow.

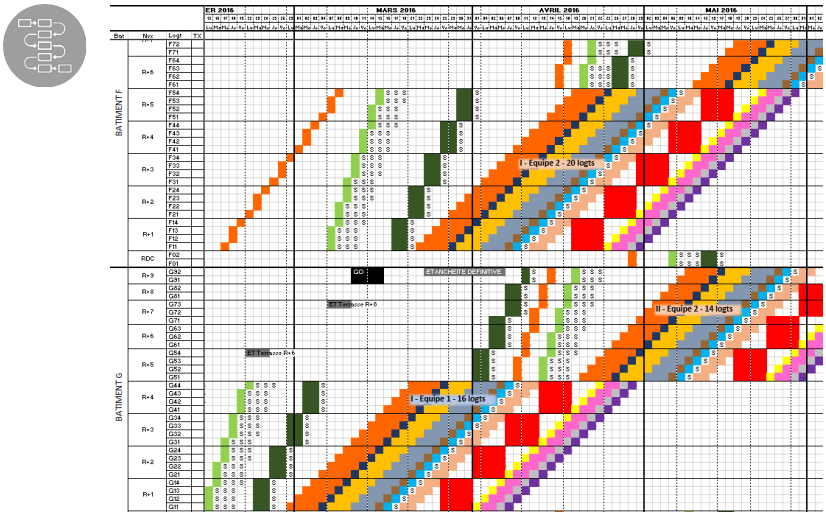

Figure E - Example of the deliverable of the collaborative planning validation

The fourth step is the more precise planning of the lean approach. Every weeks, the concerned subcontractors and the contractors have a meeting to plan the next three weeks and the potential issue that might stop the progress of works. The meeting has four main steps: (1) review of the potential issues; (2) review of the week W: then the former week W+1 becomes W and the former W+2 becomes W+1; (3) indicator Management and; (4) schedule of week W+2, as shown on Figure F.

The collaborative schedule is designed to improve the mutual communication between the stakeholders during the weekly meeting, find solution together that fits with the schedule and the interests of not only the contractor but also the subcontractors.

Coaching sessions are planned every month to ensure the collaborative weekly planning process and keep the collaborative dynamic on site. Two months before the expected delivery date, an action plan is set out to finish the project on time and aims at adapting the implemented tools to the end of the project.

Figure F - Overview of the collaborative weekly planning organization (based on internal documents)

The fifth step concerns the feedback indicators. The indicators aim at checking the progress of the works and make the link between a local vision (e.g. weekly collaborative planning) and a global vision (e.g. the time-location schedule). There are various possible indicators but the company uses mainly three indicators shown on Figure : (1) Buffer Management, (2) Percentage of promises completed and; (3) Curve S.

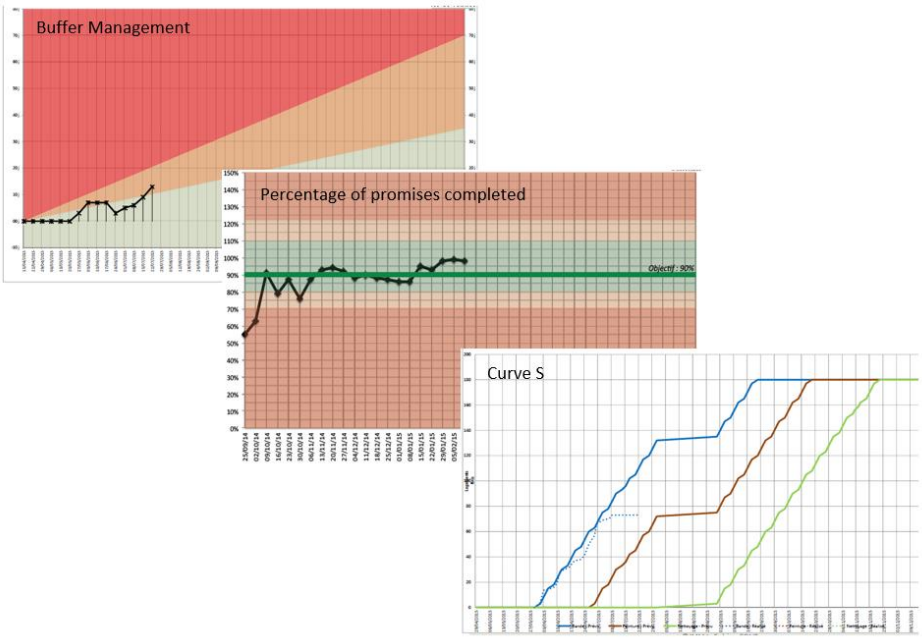

Figure G - Example of feedback indicators

Appendix 2: Scripts of the interviews

This appendix presents the original script of the interviews based on the questionnaire statement described in the methodology section in part one. The first section is the script for the subcontractors' interviews and the second section the contractor's interviews. In this appendix, BY means Bouygues the contractor company and ST means "sous-traitant" the subcontractors in French.

1. Subcontractor/ Sous-traitant

0.1/ Les ST ont été impliqués dans la préparation du planning.

0.2/ Les acteurs du projet se sont engagés sur les résultats.

0.3/ Un point planning est traité au moins chaque semaines.

0.4/ La collaboration entre les acteurs du chantier a été favorisée pour les questions de planning sur le chantier.

1.1/ Je pense qu'il n'y a pas eu de rétention d'information par les autres ST.

1.2/ Je pense qu'il n'y a pas eu de rétention d'information par l'entreprise générale (BY).

2.1/ Je pense qu'une communication ouverte et honnête m'a permis d'obtenir des informations des autres ST.

2.2/ Je pense qu'une communication ouverte et honnête m'a permis d'obtenir des informations de l'entreprise générale.

3/ La compréhension des autres partenaires a été facilité grâce aux relations de travail

4/ Je suis certain que les autres acteurs du chantier sont capables de réaliser leur tâches

5/Je pense que le chantier est mené dans une atmosphère sereine.

6.1/ Je pense que les autres ST sont professionnels et impliqués dans leur travail

6.2/ Je pense que l'entreprise générale (BY) est professionnelle et impliquée dans leur travail.

7/ Les besoins des acteurs du chantier ont été pris en comptes pour prendre les décisions important fin de trouver des compromis et obtenir des résultats satisfaisants.

8.1/ Si je partage mes problématiques avec les autres ST, je sais qu'ils y répondront de manière constructive et bienveillante.

8.2/ Si je partage mes problématiques avec l'entreprise générale (BY), je sais qu'elle y répondra de manière constructive et bienveillante.

9.1/La collaboration a été promue par la construction de bonnes et honnêtes relations avec les autres ST.

9.2/ La collaboration a été promue par la construction de bonnes et honnêtes relations avec l'entreprise générale (BY).

10.1/Je suis plus enclin à dépendre de ST de qui j'ai une bonne impression en tant que personne.

10.2/ Je suis plus enclin à dépendre d'une entreprise générale de qui j'ai une bonne impression des équipes travaux en tant que personne.

11.1/ Conserver une relation sur le long terme avec les autres ST permet d'entretenir une bonne communication.

11.2/ Conserver une relation sur le long terme avec l'entreprise générale permet d'entretenir une bonne communication.

12/ De bonnes méthodes de communication (i.e. ouvertes et fréquentes) ont permis d'éviter les ambiguïtés et détecter les divergences.

13/ Les tâches de travail demandées à chacun ont été clairement définies.

14/ La gestion du chantier a consolidé la réalisation des objectifs tout en considérant les intérêts des parties prenantes.

15/ Je pense que les entreprises avec une meilleure réputation sont plus digne de confiance puisqu'elles veulent conserver cet atout.

16/ Je tiens à la réputation de mon entreprise sur le chantier.

17/ L'avancement des travaux pendant le chantier était lissé et efficace (le double travail est éliminé) grâce à la collaboration.

18/ La résolution de problèmes est devenu efficace : les acteurs du chantier ont pris des décisions utiles.

19/ L'opération tient les délais techniques dans une atmosphère sereine.

20/ La collaboration et les relations de confiance entre les acteurs du chantier ont contribué à tenir le planning global de l'opération.

21/ Les performances du chantier en terme de planning ont été augmentées grâce à l'amélioration continue de l'organisation du travail.

22/ Les performances du chantier en terme de planning ont été améliorés grâce à d'autres facteurs. Lesquels ?

2. Contractor / Bouygues

0.1/ Les ST ont été impliqués dans la préparation du planning.

0.2/ Les acteurs du projet se sont engagés sur les résultats.

0.3/ Un point planning est traité au moins chaque semaines.

0.4/ La collaboration entre les acteurs du chantier a été favorisée pour les questions de planning sur le chantier.

1.1/ Je pense qu'il n'y a pas eu de rétention d'information par les ST.

2.1/ Je pense qu'une communication ouverte et honnête m'a permis d'obtenir des informations des ST.

3/ La compréhension des autres partenaires a été facilité grâce aux relations de travail

4/ Je suis certain que les autres acteurs du chantier sont capables de réaliser leur tâches

5/Je pense que le chantier est mené dans une atmosphère sereine.

6.1/ Je pense que les ST sont professionnels et impliqués dans leur travail

7/ Les besoins des acteurs du chantier ont été pris en comptes pour prendre les décisions important fin de trouver des compromis et obtenir des résultats satisfaisants.

8.1/ Si je partage mes problématiques avec les ST, je sais qu'ils y répondront de manière constructive et bienveillante.

9.1/La collaboration a été promue par la construction de bonnes et honnêtes relations avec les S.T.

10.1/Je suis plus enclin à dépendre de ST de qui j'ai une bonne impression en tant que personne.

11.1/ Conserver une relation sur le long terme avec les ST permet d'entretenir une bonne communication.

12/ De bonnes méthodes de communication (i.e. ouvertes et fréquentes) ont permis d'éviter les ambiguïtés et détecter les divergences.

13/ Les tâches de travail demandées à chacun ont été clairement définies.

14/ La gestion du chantier a consolidé la réalisation des objectifs tout en considérant les intérêts des parties prenantes.

15/ Je pense que les entreprises avec une meilleure réputation sont plus digne de confiance puisqu'elles veulent conserver cet atout.

16/ Je tiens à la réputation de mon entreprise sur le chantier.

17/ L'avancement des travaux pendant le chantier était lissé et efficace (le double travail est éliminé) grâce à la collaboration.

18/ La résolution de problèmes est devenu efficace : les acteurs du chantier ont pris des décisions utiles.

19/ L'opération tient les délais techniques dans une atmosphère sereine.

20/ La collaboration et les relations de confiance entre les acteurs du chantier ont contribué à tenir le planning global de l'opération.

21/ Les performances du chantier en terme de planning ont été augmentées grâce à l'amélioration continue de l'organisation du travail.

22/ Les performances du chantier en terme de planning ont été améliorés grâce à d'autres facteurs. Lesquels ?

Appendix 3: Overviews of the questionnaire results

This appendix shows an overview of the analysis results per case study and per perspective – contractor and subcontractor.

Figure H - Overview of the control sample results

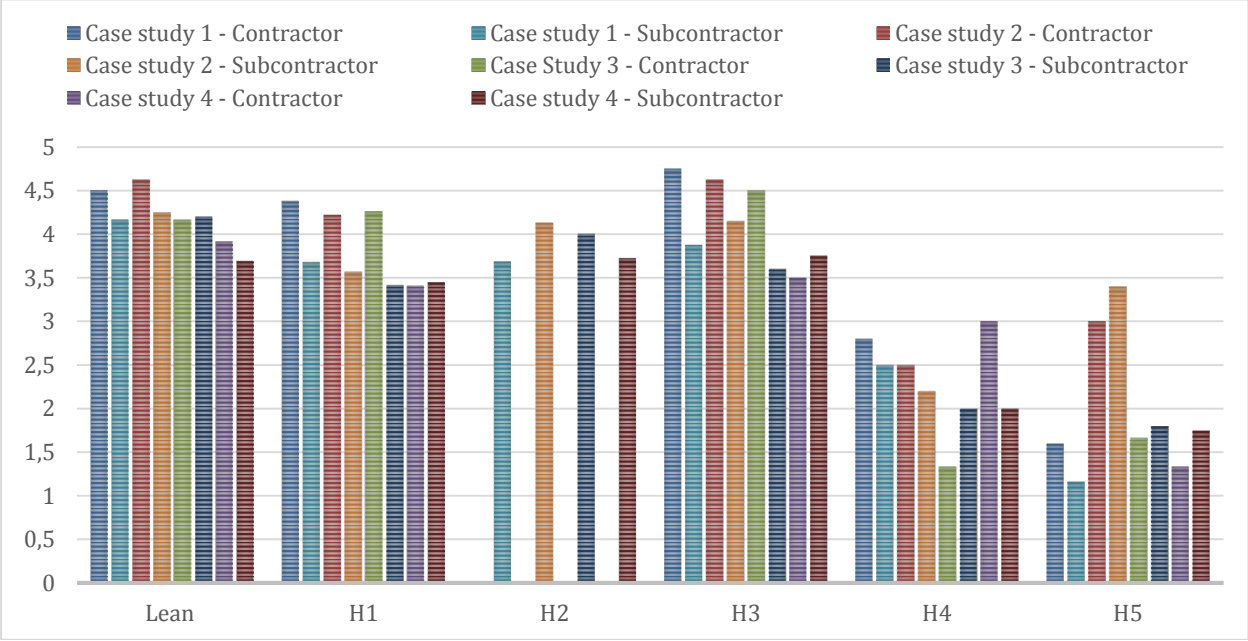

Figure I - Overview of the research sample results

Appendix 4: Interviews of project managers

Project Manager of case study 1 – April 28th

How could you explain that the subcontractor's trust scores are lower than the contractor's trust scores?

I think the answer is quite logical: the contractor chooses the subcontractors and not the other way around.

Indeed, this explanation seems to be confirmed by the trust distribution. What do you think about the results of the questionnaire on trust distribution?

Exactly, I think it is "normal" to have lower cognition-based trust from the subcontractor perspective than from the contractor perspective because the site supervisors selected the subcontractor mainly based on its competency.

That's make sense for the cognition-based trust but what about the affect-based trust?

The number of project's actors is very large: subcontractors might not know all the other subcontractors. In addition, besides competency matters, site supervisors select the subcontractor with whom they have a good relationship/feeling. This reason could explain why the affect-based trust scores are higher from the contractor's point of view than the subcontractor's point of view.

Concerning the time performance of the project, the subcontractors had scored lower this item than the subcontractor, what is the reason of this trend in your opinion?

I would say that the site supervisors do not always share all information with subcontractors concerning the completion date signed with the client because they want to keep a "safety" margin. Subsequently, according to the subcontractor the project is a bit late but in reality it is just on time.

In your opinion, what are the benefits of the lean approach?

The benefits are beyond planning issues: it has improved the collaboration, the problem solving process, the atmosphere on site, the way of communication, etc. Indeed, I believe the more brains around the table, the better solution we find. Lean approach is not magical, it is based on common sense to work in a better way all together which is essential in big project like this one.

Do you have the feeling that the questionnaire scores were overestimated due to the company head office's promotion of the lean approach?

(Laugh) That's a good question … *(Laugh)* Maybe a bit concerning the contractor. It is trust that the lean approach was launched by the head office but the project team is also convinced by the approach.

What about the subcontractors' scores?

No I don't think subcontractors' scores were influenced by the head office.

How would you improve the lean approach?

I would say the lean approach should be included in the contract with the subcontractor to avoid reluctant subcontractors as we had in our project with the plaster wall installer. The contractual integration of the lean principles should be systematic in order to ensure the commitment of all the subcontractors especially in project with a numerous subcontractors. In addition, I would like the client and the architect to be involved in the lean process.

Will you implement the lean approach in your next project?

Yes I really appreciated to work with this new method.

Project Manager of case study 2 – May, 2nd

How could you explain that subcontractors had scored higher their trust relationship with other subcontractors than with the contractor?

Indeed, I would not expect such a difference between the trust score of the subcontractors. However, it is noticeable that the atmosphere between subcontractors is really pleasant and convivial on site. This phenomenon could explain the difference of trust scores from the subcontractor's perceptive. In addition, there is a contractual relation between the subcontractor and the contractor which does not exist among subcontractors. This factor might reduce the trust relationship with the contractor due to the fear of financial sanction for instance.

From the trust distribution scores the system-based trust is scored higher from the contractor than from the subcontractor, do you have an explanation?

Based on your attributes definition, the system-based trust is partly based on the organizational policy. In my opinion, those scores can be explained by the "imposing" of the organizational policy by the contractor to the subcontractor.

Do you have the feeling that the questionnaire scores were overestimated due to the company head office's promotion of the lean approach?

You know, it is a quite small project, we all know everybody. We used to organize barbecue and breakfast. That is why, I am not surprised by the trust scores. I don't think the head office influence that much the trust scores. However, the lean approach does come from the "our" side: this could explain why the lean scores from the contractor is higher than from the subcontractors.

The interviewees highlighted the logistic effort made by the site supervisors. Do you agree with this?

Logistics is essential in this project because the stocking spaces is extremely limited. That is why the project team had emphasized on this to provide a smooth works progress and avoid blocking situation due to a lack of raw materials.

How would you improve the lean approach?

I would like to integrate more the logistic aspect to the lean approach: including the delivery planning including the volume of the raw materials, the availability of the stocking area, the stock management in collaboration with the subcontractors. I think we could complete the lean approach with the logistic approach especially in projects like this one where the stock area are extremely limited. This configuration is going to be common since the project are more and more in urbanized area.

Will you implement the lean approach in your next project?

Yes completely and certainly with a logistic application.

Project Manager of case study 3 – April, 18th

How could you explain that subcontractors had scored higher their trust relationship with other subcontractors?

I think this phenomenon can be explained by the novelty of the lean tools for the project team. They could show some doubts or not be confident enough to convince enough the subcontractor. However, it is noticeable that the difference is not that high.

Do you think the promotion of the lean approach by the head office of the company had influenced the trust scores?

Honestly, I don't know. On one hand I can't deny that communication on Lean construction was quite intense from the head office but on the other hand I do believe that the lean approach and especially the weekly planning meeting were efficient to improve collaboration and communication among actors which is in other words a trust atmosphere.

The results highlight that the contractor value more their trust relationships with the subcontractors than the subcontractors do with the contractor. According to the trust distribution this is due to the system-based trust and the affective-based trust scores, what do you think about those trends?

Concerning the system-based trust, I saw that you based this trust model on the organizational policy. Besides it is quite standardized, the organizational policy is mainly built by the contractor on construction site. Thus, I'm not surprised that the system-based trust is higher from the contractor side. Regarding the affective-based trust, the higher score from the contractor can be explained by the selection

method of subcontractors by the contractor: the site supervisors choose subcontractors they knew most of the time.

Are you surprised by the results of the questionnaire?

Not really but I did not expect the score of trust relationships among subcontractors to be that high because some subcontractors were not really cooperative. Nevertheless, I do agree on the score of the contractor questionnaire. I have the feeling that the project team trusts the subcontractors because they have developed a long term relationships with them. This is in line with the results you had concerning the trust distribution: affect-based trust seems to be quite high.

What about the time performance scores?

The contractor scored the project time performance higher than the subcontractors. This can be explained by the "safety" margins created by the contractor to ensure the completion date. The subcontractor does not always know the real completion date, so they have a biased point of the view on the project time performance. In addition, in most cases each subcontractor only focuses on his own trade planning and they don't have a global vision of the project planning.

From the subcontractor point of view, they consider their trust relationship with the other subcontractors stronger than with the contractor, how could you explain this?

To be honest, I don't know. One reason could be that the subcontractors used to work together.

In your opinion, what are the benefits of the lean approach?

I think the main benefit concerns the improvement of communication among actors and especially between contractors. The communication is less central and subcontractors fix their minor issues without the help of the site supervisor. For example, the tile setter and the painter had major interactions: during the weekly planning meeting they succeeded in setting work plan adapted to the following weeks. This communication prevent the project team from a typical waste of time.

How would you improve the lean approach?

I think the duration of the weekly planning session is way too long and I would advise to keep those meetings focused on planning issues. In this project, at the beginning those meetings were about half an hour because there were only a couple of subcontractors. But now the planning meetings are about one hour / one hour and a half which is too long for the subcontractors: they have the feeling to waste their time with the other subcontractor's issues. They were not always present by skipping it occasionally. Subsequently, we have decided with the project team to divide the planning meeting into two or three smaller groups of subcontractors with high degree of interaction. This solution is not perfect because some subcontractors are concerned by the discussion in the two or more groups

such as plumber, electrician, etc.. However, this alternative works better on our project and subcontractor are more present on a regular basis.

Will you implement the lean approach in your next project?

Yes, I think it will work even better when the project's actors are used to implement it.

Project Manager of case study 4 – April, 22nd

How could you explain the fact that the subcontractor scored higher their trust relationship with other subcontractors than trust relationships with the contractor?

The difference is not significant. I would say the both sides scored the trust relationship quite high.

Are you surprised by the scores?

Not at all. The scores are quite homogeneous in my opinion. My only remarks concerns the time project performance's scores: the subcontractors scored it slightly higher than the contractor which is a bit surprising. I would expect my project team to be more optimistic (*laughing*).

What about the scores concerning the continuous improvements? The subcontractors scored this item lower than the site supervisors

On this project we changed the administrative procedure to report employee list online. This new administrative tools was very innovative for the human management for the subcontractors.

Do you think the head office had influenced the scores by promoting the lean approach?

This is something to take into account of course. However, I am not convinced concerning the impact on the score especially on the subcontractors' scores. It might have impacted the contractor's score but I am doubtful.

How would you improve the lean approach?

I think we were a bit too optimistic at the beginning. We had drawn a very ambitious planning with the subcontractors. During the execution we had realized it was too tensed and too short to be realistic. In addition the weekly planning session was too much detailed and took too much time considering the availability of the subcontractors. We do not work to improve the implementation of the lean approach but we implement the lean approach to improve our way to work. Thus, we have decided to simplify the process. First with the weekly planning meeting, we only focus on a couple of weeks with the foremen (no more). Secondly, the planning was initially per apartment, we had decided to zoom out and consider the

entire floor. Those settings made the approach less heavy to implement and more flexible.

Will you implement the lean approach in your next project?

I think so but in a simplified way.

Project Manager of case study 5 – April, 22nd

How could you improve the planning process?

I would like more anticipation concerning the planning. I had the feeling that we spent more time on dealing with problem than anticipate potential issues in advance.

How could you do to improve anticipation?

In my opinion the main problem concerns information on potential issues: each party prefers to hide his own problem rather than sharing it to find a solution.

What can you do to promote it?

I guess this is a matter of communication and project management. I think it depends highly on the subcontractors as well.

Here are the results of the questionnaire, what do you think about?

I am not surprised. I do agree that trust relationship can be improved between the project's actors. However, the results on the time performance of the project seem to be very low.

Why do the project time performance score lower than you expect?

I would say this is because we are very ambitious on the early stage to create spare time before the delivery date. The opportunistic behaviour of certain subcontractors creates uncertainty on the planning: some subcontractors wait to start to be sure to not be blocked by other trades, and then speed up to catch up the contractual date with an "army" of workers. In addition, the client took some time to determine final choice of buyers.

What is your opinion on the results of the project time performance?

I think your results from the subcontractors are correct because they were quite late based on the planning we provide them. I am more surprised by the results from the contractor project team's answer because they know the real delivery date behind the planning we provide to the subcontractors.

Why don't you share the official delivery date with the subcontractor?

From my experience, the subcontractors will always wait the last moment to perform their works as I explained earlier. To prevent the project from delays, I

prefer to not communicate on the delivery date and set end date of the trade works before. Delays are very costly for the company and need to be avoided. That's the role of the site works supervisors.

From the subcontractor's questionnaire results, they consider their trust relationships with the contractor stronger than with the other subcontractors; do you agree with this result?

Yes, because the communication is very limited among the subcontractors on planning issues. On site, the communication is centred on the site supervisors, compartmented by trades.

Project Manager of case study 7 – April, 27th

What do you think about the results of the questionnaire?

I interpret the results as the translation of the suspicious atmosphere on site. Concerning the continuous improvement scores, this could be explained by the special effort of the project team to developed logistic aspects.

How could you improve the planning process?

As mentioned in the previous question, the logistic aspects are key element in the planning process. The logistic is highly related to the planning and needs to be taken into account from the planning design to the execution.

How could you explain the trust distribution difference between the contractor perceptive and the subcontractor perceptive?

The cognition-based trust is higher from the contractor perspective because the works supervisors select the subcontractors and not the other way around. The choice of the project team does not include the other subcontractors. Concerning the affect-based trust, I would say the two score are quite similar. This phenomenon is clearly identified on site: the subcontractors and the works supervisors used to work all together.

What about the time performance of the project?

Yes, I see what you point out. Of course I expected those scores to be higher and especially concerning the contractor side. However, I have to admit that the project is falling behind schedule due to different issues. We hope to catch up the planning before the end of the works.

Appendix 5: Questionnaire scores

Formulas explanation

For each type of questionnaire (either contractor or subcontractor), the scores collected are weighted average to be comparable depending on:

- The number of statements per hypothesis (or trust model)
- The number of questionnaire scores per project
- The number of project

The scores are shown on the two tables below.

Contractor scores

Research Sample

	#	S0.1	S0.2	S0.3	S0.4	S1.1	S2.1	S3	S4	S5	S6.1	S7	S8.1	S9.1	S10.1	S11.1	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	Lean	H1		H3	H4	H5	Cognition-based trust	Affect-based trust	System-based trust
Project 1 - CL	1	5	3	4	5	3	5	4	5	5	3	4	5	5	5	4	5	5	5	3	3	5	5	5	4	2	3	17	39		19	2	3	25	23	21
	2	5	4	5	4	5	4	3	5	4	4	5	5	4	4	4	4	5	4	2	2	5	5	4	5	3	2	18	40		19	3	2	25	22	17
	3	5	4	5	5	3	3	4	4	5	4	4	4	4	5	3	2	5	3	3	3	5	4	5	4	3	1	19	34		18	3	1	23	20	16
	4	4	3	5	5	4	5	4	5	5	4	3	5	5	4	5	3	4	2	2	4	5	5	5	5	3	1	17	40		20	3	1	27	22	15
	5	5	4	5	5	5	5	4	5	5	5	5	5	5	5	4	5	5	5	4	5	4	5	5	5	3	1	19	44		19	3	1	29	24	24
	TOT	24	18	24	24	20	22	19	24	24	20	21	24	23	23	20	19	24	19	14	17	24	24	24	23	14	8	90	197		95	14	8	129	111	93
																							Weighted total					4,5	4,3778		4,75	2,8	1,6	4,3	4,44	3,72
Project 2 - LEV	6	4	4	5	5	4	5	4	5	4	4	3	5	5	3	4	5	5	4	3	5	5	4	4	4	2	3	18	38		17	2	3	26	20	22
	7	5	5	4	5	3	4	4	4	4	4	5	4	5	4	5	5	3	4	4	3	5	5	5	5	3	3	19	38		20	3	3	23	23	19
	TOT	9	9	9	10	7	9	8	9	8	8	8	9	10	7	9	10	8	8	7	8	10	9	9	9	5	6	37	76		37	5	6	49	43	41
																							Weighted total					4,625	4,2222		4,625	2,5	3	4,08333333	4,3	4,1
Project 3 -IV	8	4	4	5	4	3	5	4	5	5	4	4	4	5	5	5	5	5	4	4	4	5	5	5	4	1	2	17	40		19	1	2	26	23	22
	9	3	3	5	5	4	3	3	4	5	3	4	4	4	4	5	3	5	3	3	5	4	4	4	5	2	1	16	35		17	2	1	22	21	19
	10	5	3	5	4	4	4	5	4	4	4	5	4	5	5	5	4	5	4	4	3	4	5	5	4	1	2	17	40		18	1	2	25	24	20
	TOT	12	10	15	13	11	12	12	13	14	11	13	12	14	14	15	12	15	11	11	12	13	14	14	13	4	5	50	115		54	4	5	73	68	61
																							Weighted total					4,166667	4,2593		4,5	1,333	1,666667	4,05555556	4,53333333	4,06666667
Project 4 - ME	11	5	3	3	4	4	5	3	5	4	5	5	3	5	5	3	4	5	4	4	5	3	3	5	5	4	1	15	40		16	4	1	26	21	22
	12	4	4	4	5	3	3	4	3	3	3	4	3	3	4	4	3	3	3	2	3	3	5	4	4	3	2	17	30		16	3	2	19	18	14
	13	4	4	4	3	3	3	2	2	4	2	3	3	2	2	2	2	3	3	1	3	2	2	3	3	2	1	15	22		10	2	1	16	12	12
	TOT	13	11	11	12	10	11	9	10	11	10	12	9	10	11	9	9	11	10	7	11	8	10	12	12	9	4	47	92		42	9	4	61	51	48
																							Weighted total					3,916667	3,4074		3,5	3	1,333333	3,38888889	3,4	3,2
Total		29	25	31	29	24	28	25	28	30	25	29	25	29	30	29	26	31	25	22	27	26	29	31	29	14	11	17,20833	16,267		17,375	9,633	7,6	15,8277778	16,6733333	15,0866667
																												Weighted total	4,3021	4,07	4,344	2,41	1,9	3,956944	4,168333	3,771667

Control Sample

	#	S0.1	S0.2	S0.3	S0.4	S1.1	S2.1	S3	S4	S5	S6.1	S7	S8.1	S9.1	S10.1	S11.1	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	Lean	H1		H3	H4	H5	Cognition-based trust	Affect-based trust	System-based trust
Project 5 - SU	14	1	4	2	1	3	2	3	3	2	3	3	2	3	2	2	3	4	3	2	4	2	1	3	2	2	1	8	23		8	2	1	16	12	16
	15	3	2	3	1	2	3	2	5	3	2	2	3	2	3	3	3	3	3	3	3	4	2	3	4	3	1	9	25		13	3	1	17	13	15
	16	3	2	3	2	3	2	1	4	3	4	2	2	2	2	2	2	3	4	2	2	3	3	2	2	2	2	10	23		10	2	2	17	10	13
	TOT	7	8	8	4	8	7	6	12	8	9	7	7	7	7	7	8	10	10	7	9	9	6	8	8	7	4	27	71		31	7	4	50	35	44
																							Weighted total					2,25	2,6296		2,5833	2,333	1,333333	2,77777778	2,33333333	2,93333333
Project 6 - AU	17	3	3	2	3	2	3	4	2	2	3	3	2	3	2	1	3	4	4	3	4	2	3	3	3	2	1	11	21		11	2	1	16	11	18
	18	2	2	3	1	3	2	3	3	3	3	1	2	2	3	2	1	1	3	2	1	4	1	4	4	2	3	8	21		13	2	3	17	10	8
	19	2	2	1	3	1	1	2	4	4	2	1	1	3	2	2	4	4	3	3	4	3	2	2	3	3	1	8	17		10	3	1	14	9	18
	TOT	7	7	6	7	6	6	9	9	9	8	5	5	8	7	5	8	9	10	8	9	9	6	9	10	7	5	27	59		34	7	5	47	30	44
																							Weighted total					2,25	2,1852		2,8333	2,333	1,666667	2,61111111	2	2,93333333
Project 7 - PA	20	2	1	2	1	3	2	2	4	4	3	3	2	3	1	3	3	2	4	2	2	2	3	2	3	3	1	6	24		10	3	1	18	12	13
	21	3	2	3	2	3	2	3	3	4	3	2	2	4	2	2	3	3	3	2	3	3	2	4	4	2	1	10	23		13	2	1	18	12	14
	22	2	3	2	3	2	3	3	2	3	2	4	3	2	2	3	3	3	2	2	3	4	4	2	4	2	2	10	23		14	2	2	15	14	13
	23	3	1	3	3	2	2	1	3	3	3	2	3	1	2	2	2	2	2	2	3	3	3	2	2	2	2	10	20		10	2	2	14	10	11
	TOT	10	7	10	9	10	9	9	12	14	11	11	10	10	7	10	11	10	11	8	11	12	12	10	13	9	6	36	90		47	9	6	65	48	51
																							Weighted total					2,25	2,5		2,9375	2,25	1,5	2,70833333	2,4	2,55
Total		24	22	24	20	24	22	24	33	31	28	23	22	25	21	22	27	29	31	23	29	30	24	27	31	23	15	6,75	7,3148		8,3542	6,917	4,5	8,09722222	6,73333333	8,41666667
																												Weighted total	2,25	2,44	2,785	2,31	1,5	2,699074	2,244444	2,805556

	Lean	H1	H3	H4	H5	Cognition-based trust	Affect-based trust	System-based trust
Relative diff	0,476998	0,4004	0,3589	0,043	0,210526	0,31788932	0,46154871	0,25614965
Abs diff	2,052083	1,6284	1,559	0,103	0,4	1,25787037	1,92388889	0,96611111

Research Sample

	#	S0.1	S0.2	S0.3	S0.4	S1.1	S2.1	S3	S4	S5	S6.1	S7	S8.1	S9.1	S10.1	S11.1	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	Lean	H1		H3	H4	H5	Cognition-based trust	Affect-based trust	System-based trust
Project 1 - CL	1	5	3	4	5	3	5	4	5	5	3	4	5	5	5	4	5	5	5	3	3	5	5	5	4	2	3	17	39		19	2	3	25	23	21
	2	5	4	5	4	5	4	3	5	4	4	5	5	4	4	4	4	5	4	2	2	5	4	5	4	3	2	18	40		19	3	2	25	22	17
	3	5	4	5	5	3	3	4	4	5	4	4	4	4	5	3	2	5	3	3	3	5	4	5	4	3	1	19	34		18	3	1	23	20	16
	4	4	3	5	5	4	5	4	5	5	4	3	5	5	4	5	3	4	2	2	4	5	5	5	5	3	1	17	40		20	3	1	27	22	15
	5	5	4	5	5	5	5	4	5	5	5	5	5	5	5	4	5	5	5	4	5	4	5	5	5	3	1	19	44		19	3	1	29	24	24
	TOT	24	18	24	24	20	22	19	24	24	20	21	24	23	23	20	19	24	19	14	17	24	24	24	23	14	8	90	197		95	14	8	129	111	93
																							Weighted total					4,5	4,3778		4,75	2,8	1,6	4,3	4,44	3,72
Project 2 - LEV	6	4	4	5	5	4	5	4	5	4	4	3	5	5	3	4	5	5	4	3	5	5	4	4	4	2	3	18	38		17	2	3	26	20	22
	7	5	5	4	5	3	4	4	4	4	4	4	5	4	5	4	5	5	3	4	4	3	5	5	5	3	3	19	38		20	3	3	23	23	19
	TOT	9	9	9	10	7	9	8	9	8	8	8	9	10	7	9	10	8	8	7	8	10	9	9	9	5	6	37	76		37	5	6	49	43	41
																							Weighted total					4,625	4,2222		4,625	2,5	3	4,08333333	4,3	4,1
Project 3 -IV	8	4	4	5	4	3	5	4	5	5	4	4	4	5	5	5	5	5	4	4	4	5	5	5	4	1	2	17	40		19	1	2	26	23	22
	9	3	3	5	5	4	3	3	4	5	3	4	4	4	4	5	3	5	3	3	5	4	4	4	5	2	1	16	35		17	2	1	22	21	19
	10	5	3	5	4	4	4	5	4	4	4	5	4	5	5	5	4	5	4	4	3	4	5	5	4	1	2	17	40		18	1	2	25	24	20
	TOT	12	10	15	13	11	12	12	13	14	11	13	12	14	14	15	12	15	11	11	12	13	14	14	13	4	5	50	115		54	4	5	73	68	61
																							Weighted total					4,166667	4,2593		4,5	1,333	1,666667	4,05555556	4,53333333	4,06666667
Project 4 - ME	11	5	3	3	4	4	5	3	5	4	5	5	3	5	5	3	4	5	4	4	5	3	3	5	5	4	1	15	40		16	4	1	26	21	22
	12	4	4	4	5	3	3	4	3	3	3	4	3	3	4	4	3	3	3	2	3	3	5	4	4	3	2	17	30		16	3	2	19	18	14
	13	4	4	4	3	3	3	2	2	4	2	3	3	2	2	2	2	3	3	1	3	2	2	3	3	2	1	15	22		10	2	1	16	12	12
	TOT	13	11	11	12	10	11	9	10	11	10	12	9	10	11	9	9	11	10	7	11	8	10	12	12	9	4	47	92		42	9	4	61	51	48
																							Weighted total					3,916667	3,4074		3,5	3	1,333333	3,38888889	3,4	3,2
Total		29	25	31	29	24	28	25	28	30	25	29	25	29	30	29	26	31	25	22	27	26	29	31	29	14	11	17,20833	16,267		17,375	9,633	7,6	15,8277778	16,6733333	15,0866667
																												Weighted total	4,3021	4,07	4,344	2,41	1,9	3,956944	4,168333	3,771667

Control Sample

	#	S0.1	S0.2	S0.3	S0.4	S1.1	S2.1	S3	S4	S5	S6.1	S7	S8.1	S9.1	S10.1	S11.1	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	Lean	H1		H3	H4	H5	Cognition-based trust	Affect-based trust	System-based trust
Project 5 - SU	14	1	4	2	1	3	2	3	3	2	3	3	2	3	2	2	3	4	3	2	4	2	1	3	2	2	1	8	23		8	2	1	16	12	16
	15	3	2	3	1	2	3	2	5	3	2	2	3	2	3	3	3	3	3	3	3	4	2	3	4	3	1	9	25		13	3	1	17	13	15
	16	3	2	3	2	3	2	1	4	3	4	2	2	2	2	2	2	3	4	2	2	3	3	2	2	2	2	10	23		10	2	2	17	10	13
	TOT	7	8	8	4	8	7	6	12	8	9	7	7	7	7	7	8	10	10	7	9	9	6	8	8	7	4	27	71		31	7	4	50	35	44
																							Weighted total					2,25	2,6296		2,5833	2,333	1,333333	2,77777778	2,33333333	2,93333333
Project 6 - AU	17	3	3	2	3	2	3	4	2	2	3	3	2	3	2	1	3	4	4	3	4	2	3	3	3	2	1	11	21		11	2	1	16	11	18
	18	2	2	3	1	3	2	3	3	3	3	1	2	2	3	2	1	1	3	2	1	4	1	4	4	2	3	8	21		13	2	3	17	10	8
	19	2	2	1	3	1	1	2	4	4	2	1	1	3	2	2	4	4	3	3	4	3	2	2	3	3	1	8	17		10	3	1	14	9	18
	TOT	7	7	6	7	6	6	9	9	9	8	5	5	8	7	5	8	9	10	8	9	9	6	9	10	7	5	27	59		34	7	5	47	30	44
																							Weighted total					2,25	2,1852		2,8333	2,333	1,666667	2,61111111	2	2,93333333
Project 7 - PA	20	2	1	2	1	3	2	2	4	4	3	3	2	3	1	3	3	2	4	2	2	2	3	2	3	3	1	6	24		10	3	1	18	12	13
	21	3	2	3	2	3	2	3	3	4	3	2	2	4	2	2	3	3	3	2	3	3	2	4	4	2	1	10	23		13	2	1	18	12	14
	22	2	3	2	3	2	3	3	2	3	2	4	3	2	2	3	3	3	2	2	3	4	4	2	4	2	2	10	23		14	2	2	15	14	13
	23	3	1	3	3	2	2	1	3	3	3	2	3	1	2	2	2	2	2	2	3	3	3	2	2	2	2	10	20		10	2	2	14	10	11
	TOT	10	7	10	9	10	9	9	12	14	11	11	10	10	7	10	11	10	11	8	11	12	12	10	13	9	6	36	90		47	9	6	65	48	51
																							Weighted total					2,25	2,5		2,9375	2,25	1,5	2,70833333	2,4	2,55
Total		24	22	24	20	24	22	24	33	31	28	23	22	25	21	22	27	29	31	23	29	30	24	27	31	23	15	6,75	7,3148		8,3542	6,917	4,5	8,09722222	6,73333333	8,41666667
																												Weighted total	2,25	2,44	2,785	2,31	1,5	2,699074	2,244444	2,805556

	Lean	H1	H3	H4	H5	Cognition-based trust	Affect-based trust	System-based trust
Relative diff	0,476998	0,4004	0,3589	0,043	0,210526	0,31788932	0,46154871	0,25614965
Abs diff	2,052083	1,6284	1,559	0,103	0,4	1,25787037	1,92388889	0,96611111

Appendix 6: Analysis of the interviews

Besides the scores from the questionnaire, the interviewees provided extra information to underpin their scores. The table below summarized the findings from interviews in each case.

		H1	H2	H3	H4/H5	Suggested Improvements / General remarks
Case study 1	Interviewee 1 – contractor	The WWP meeting is essential to promote collaboration and communication concerning the planning	/	The lean approach increased the communication between the subcontractors despite the size of the project	Continuous improvements took place as in the common situation	Designation of contact members among the project team to improve communication
	Interviewee 2 – contractor	WWP meeting on Thursday helped to develop collaboration on planning and logistics	/	The more brains joined into the problem solving the better is the solution	Continuous improvements took place as in the normal situation	The size of the project makes the communication complex not only with the subcontractors but also among the site supervisors team.
	Interviewee 3 – contractor	WWP meetings helped to promote collaboration but some aspects are not taken into account that leads to some ambiguity	/	Sharing information on difficulties during Thursday meetings improved the problem solving process	Continuous improvements took place as in the regular situation	Considering the size of the project, the communication is essential to promote collaboration and improve problem solving concerning the planning
	Interviewee 4 – contractor	WWP Thursday does not sufficiently work yet	/	The involvement of the subcontractor improves the problem solving during Thursday meetings	Continuous improvements took place as usually	Simplification of the approach (shorten the Thursday meetings)
	Interviewee 5 – contractor	Thursday meetings improved the communication with the subcontractors and the project team	/	Logistic aspect helped to smooth the work flow and increased the efficiency of the project team	Continuous improvements took place as in the normal situation	Involving more actor into the approach
	Interviewee 1 – subcontractor	Through the new approach the relation between us and the contractor team is more transparent and constructive to find planning solution.	Thursday meeting improved communication among the subcontractors	Subcontractors were more involved in the problem solving process	/	Thursday meetings could have been more structured to be less time consuming

	Interviewee 2 – subcontractor	Thursday meeting were very useful to prepare our work in advance and anticipate any modification in the planning	Thursday meeting improved communication among the subcontractors	Subcontractors were more involved in the problem solving process	/	The approach helps to prepare my work and anticipate changes
	Interviewee 3 – subcontractor	The communication with the contractor project team was quite complex because of the structural works quality issues but the lean approach helped to improve it	The Thursday meetings allow us to understand the need and constraint of other trades besides the size of the project	The approach helped to avoid misunderstanding and improved communication through the involvement of the subcontractors in the problem solving process	/	The priority should be given to the quality issues rather than to the new innovative approach
	Interviewee 4 – subcontractor	Through the new approach the relation between us and the contractor team is more transparent and constructive to find planning solution.	Thursday meeting improved communication among the subcontractors	The approach helped to avoid misunderstanding and improved communication through the involvement of the subcontractors in the problem solving process	/	The size of the project makes communication among the subcontractor very complex
	Interviewee 5– subcontractor	The communication with the contractor project team was quite complex because of the structural works quality issues	The size of the project limits the communication and constructive interaction among the subcontractors despite the new approach	I expected to be more involved	The administrative procedure about the insulation certification is considered as a continuous improvement impacting the project performance	/
	Interviewee 6 – subcontractor	The communication with the contractor improved but I would expect more understanding towards the administrative procedure	Thursday meetings improved communication among the subcontractors	The approach helped to avoid misunderstanding and improved communication through the involvement of the subcontractors in the problem solving process	/	/

		H1	H2	H3	H4/H5	Suggested Improvements / General remarks
Case study 2	Interviewee 6 – contractor	I have already work with most of the subcontractors	/	Logistic aspects help to ensure the planning	Logistic can be considered as a continuous improvement	Logistic aspect should be included in the lean planning approach
	Interviewee 7 – contractor	Tuesday meetings and logistics reflection involved completely the subcontractors into the planning process	/	Anticipation concerning planning and logistics help to improve the project time performance	Logistic can be considered as a continuous improvement	Logistic aspect should be included in the lean planning approach
	Interviewee 7 – subcontractor	Tuesday meetings helped to find collaborative solutions and anticipate blocking situation	I have already worked with most of the subcontractors	The subcontractors were more involved in the problem solving process	Logistic can be considered as a continuous improvement	Logistic aspect should be included in the lean planning approach
	Interviewee 8 – subcontractor	The Tuesday meetings and other planning meetings create the opportunity to highlight potential issues	I have already worked with most of the subcontractors : the working atmosphere is really pleasant	The subcontractors were more involved in the problem solving process	Logistic can be considered as a continuous improvement	Logistic aspect should be included in the lean planning approach
	Interviewee 9 – subcontractor	Tuesday meetings helped to find collaborative solution and anticipate any blocking situation with the contractor	It is easier to understand other subcontractors constraints and working method during the Tuesday meetings	The subcontractors were more involved in the problem solving process	Logistic can be considered as a continuous improvement	Logistic aspect should be included in the lean planning approach
	Interviewee 10 – subcontractor	Logistic aspect developed by the contractor was very appreciated	The atmosphere is very pleasant with the other subcontractors	The subcontractors were more involved in the problem solving process	/	/
	Interviewee 11 – subcontractor	The approach is not perfect but I agree it help to promote communication but not the work flow	The atmosphere is very pleasant with the other subcontractors	The subcontractors were more involved in the problem solving process	/	Room for improvement to smooth the work flow

		H1	H2	H3	H4/H5	Suggested Improvements / General remarks
Case Study 3	Interviewee 8 – contractor	Communication improves among the subcontractors concerning planning	/	Collaboration is a key to planning success	/	Thursday meetings are too long : some subcontractors stop attending the meeting for this reason
	Interviewee 9 – contractor	The Thursday meetings and the involvement of the subcontractors into the planning process help to promote collaboration and problem solving with and among the subcontractors concerning the planning	/	The project is going well concerning the planning	/	Dividing the Thursday meeting into two meetings might be a solution to reduce the duration
	Interviewee 10 – contractor	Most of the subcontractors enter into the approach in a constructive way	/	Collaboration was a key to the planning success	/	The approach is not adapted to the facade
	Interviewee 12 – subcontractor	The communication improved especially during the Thursday meeting	The communication improved especially during the Thursday meeting	Completion target date will be okay	/	/
	Interviewee 13 – subcontractor	The communication improved especially during the Thursday meeting	The communication improved especially during the Thursday meeting	/	/	The Thursday meeting are time consuming. I suggest to reduce the duration
	Interviewee 14 – subcontractor	The communication improved especially during the Thursday meeting	The communication improved especially during the Thursday meeting	Involvement of the subcontractor in the problem solving process	/	Thursday meeting are too long and each subcontractors only cares about his own interest
	Interviewee 15 – subcontractor	Lack of communication and lot of ambiguities with the contractor team	People never do what they said	/	/	The new approach is a waste of time I prefer the traditional way to plan works
	Interviewee 16 – subcontractor	The communication with the contractor improved thanks to the Thursday meeting	Communication with the subcontractors improved during the Thursday meeting	/	/	Involvement of more project's actors : client architects to reduce redundant works

		H1	H2	H3	H4/H5	Suggested Improvements / General remarks
Case Study 4	Interviewee 11 – contractor	Most of the subcontractors were collaborative on planning issues in a constructive atmosphere	/	The project is on time	/	The principles of lean are very wise but in practice it is not simple to applied in a specific project
	Interviewee 12 – contractor	Thursday meeting promotes collaboration with subcontractors	/	The project planning is going well	/	Doubtful at the beginning but now convinced on the impact of lean on communication and collaboration with the subcontractor
	Interviewee 13 – contractor	WWP on Thursday helped to improve the relationships with the subcontractors concerning planning through collaboration	/	The project schedule is great but the atmosphere could be better	/	The simplification of the approach
	Interviewee 17 – subcontractor	The Thursday meeting promoted the communication	/	/	The new administrative procedure online is perceived as continuous improvement	The approach helped to understand the needs and constraints of other actors
	Interviewee 18 – subcontractor	The Thursday meeting avoid ambiguity and promote communication	I am more aware of other subcontractor's constraint and working strategy	The subcontractors are involved in the planning process	/	The Thursday meetings are very time consuming and it should be shorten to be more efficient
	Interviewee 19 – subcontractor	Contractor are more transparent with the new approach	/	/	/	I fell less passive actors in the project thanks to the approach. Involvement of the subcontractor since the early stage of the planning process
	Interviewee 20 – subcontractor	Some contractor team members are sneaky	No interaction with other subcontractors		/	The new approach was not adapted to the façade works

		H1	H2	H3	H4/H5	Suggested Improvements / General remarks
Case Study 5	Interviewee 14 – contractor	Even though, we used to work with most of them, the subcontractors are not very cooperative with us and communication is mainly based on written means.	/	The completion is ensured in my opinion	/	The relationships with the subcontractors need to be balanced between the contractual bindings and the partnership development
	Interviewee 15 – contractor	The involvement of the subcontractor in the planning process is quite limited because they are not always transparent with the contractor team	/	There is no issue on the planning currently	/	The subcontractor should be more transparent with the contractor team towards the planning issues
	Interviewee 16 – contractor	The leadership of the contractor team is essential to control and communicate on the subcontractor's work	/	/	/	The contractor needs to structure the planning towards subcontractors
	Interviewee 21 – subcontractor	I used to work with the contractor team	The other subcontractors always wanted to protect their interest over the project's interests	The project planning is going well but	/	The contractor team protect its own interest but for instance using written communication
	Interviewee 22 – subcontractor	The contractor did not involve the subcontractor in the planning process from design to execution	Communication with other subcontractor i: limited	Redundant work on planning could have been avoided	/	Involvement of the subcontractor into the planning process since the early stage
	Interviewee 23 subcontractor	The contractors did not really open the planning process to subcontractors. Communication channels are mainly email and phone calls	Most of the subcontractors wanted to protect their interest over the project's interests : wait to have work available on site and then speed up to catch the contractual date	Some trades are quite late and other are not…	The new administrative procedure as continuous improvement	Diversification of the communication channel to promote more interaction with other project's actors
	Interviewee 24 subcontractor	The contractors did not really open the planning process to subcontractors.	Most of the subcontractors wanted to protect their interest over the project's interests	Collaboration is limited regarding planning issues	/	Collaboration among the project's actors could help to smooth
	Interviewee 25 subcontractor	The communication with the contractor is quite limited	The relation with other subcontractors is very limited	/	/	/

		H1	H2	H3	H4/H5	Suggested Improvements / General remarks
Case Study 6	Interviewee 17 – contractor	The communication with the subcontractors are a bit tensed and centered on the project team and thus compartmented per trades	/	There is room for improvement : redundant works collaboration	/	We want to avoid opportunistic behavior from subcontractors : wait to accumulate available space and speed up to catch the contractual date which blocks the next trades
	Interviewee 18 – contractor	The relation with the subcontractors is currently tensed : they are focused on their own interest	/	The subcontractors are not always involved into the problem solving process	The new administrative procedure was considered as a continuous improvement	The atmosphere could be much better. Our position as contractor is not always comfortable : we have to be exigent
	Interviewee 19 – contractor	The bankruptcy of one of the subcontractors damaged the atmosphere on site	/	/	/	Subcontractors do not seem collaborative on planning issues (protection of their own interests)
	Interviewee 26 – subcontractor	The communication channel is very vertical and the subcontractors are not expected to participate to the planning process	Since the bankruptcy of one of the subcontractors I started to doubt on the competency and financial health of the other subcontractors to perform the work	The works flows were not smooth and lack anticipation particularly towards the structural works	/	Planning issues is very compartmented and information flows are very limited
	Interviewee 27 – subcontractor	I used to work with most of the members of the contractor team	The relation with other subcontractors is very limited	/	/	The involvement of the subcontractor in the planning process could be a good idea to make planning reliable
	Interviewee 28 – subcontractor	The atmosphere on site was very tensed especially since the bankruptcy of one of the subcontractors	The relation with other subcontractors is very limited	Redundant works seem to be very time consuming. The subcontractors were not involved in the planning process	/	The planning missed anticipation especially concerning the structural works delays
	Interviewee 29 – subcontractor	My relationship with the contractor team was very professional and transparent	I have collaborated with the other facade trades	The subcontractor should be more involved in the planning process to improve the project time performance	/	The designation process from the contractor might be not completely efficient

	Interviewee 30 – subcontractor	I feel a lot of pressure from the contractor since the bankruptcy of last week	The relation with other subcontractors is very limited	I am doubtful about the completion date and I think the first design of the planning from the contractor was too optimistic	/	The working atmosphere could be more convivial and less tensed in my opinion

		H1	H2	H3	H4/H5	Suggested Improvements / General remarks
Case Study 7	Interviewee 20 – contractor	The main communication channel is emails and phone calls	/	The subcontractor found "optimal" solution as they have an "expert" eye on the situation	/	The project planning is very tight
	Interviewee 21 – contractor	The atmosphere with the subcontractors is good but collaboration is very limited	/	Logistics aspects developed to smooth the subcontractors' works	/	Improvement of the communication by reducing the number of phone calls would be appreciated
	Interviewee 22 – contractor	We used to work with most of the subcontractors and we have chosen to keep them for the second part of the project	/	Logistics considerations help to improve the project time performance	/	Improvement the medium term vision of the project
	Interviewee 23 – contractor	/	/	Logistics was an essential aspect to develop with the subcontractors to improve time performance	/	/
	Interviewee 31 – subcontractor	We know the contractor team quite well already but the communication channel is not enough flexible	I used to work with the other subcontractor	Logistic consideration helped a lot but some previous delays make me doubtful on the completion date	Logistic aspect is part of the continuous improvement in my opinion	Lack of anticipation concerning planning
	Interviewee 32 – subcontractor	I have already worked with the project team	I know most of the subcontractors from previous project but I don't really share with them		/	I would like to be involved more in the planning process
	Interviewee 33 – subcontractor	I used to work with the project team	I knew some of the other subcontractors	Redundant works were the reason for some project delays	/	/
	Interviewee 34 – subcontractor	I have already worked with the project team	I know most of the subcontractors from previous project but I don't really share information with them	Our involvement in the problem solving process is quite limited	Logistic aspect is part of the continuous improvement in my opinion	More regular meeting (face-to-face) to define a clear medium term vision of the planning
	Interviewee 35 – subcontractor	The atmosphere with the contractor is a bit tensed due to the critical path delays	/	The works on the façade were not smooth at all	/	/