The contribution of subcontractor involvement in continuous improvement programs for industrialised housebuilding

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Abstract

The involvement of subcontractors with their specific knowledge to on-site processes in continuous improvement (CI) programs seems beneficial. Despite known advantages for developing corporate standards and processes, the collaboration between subcontractors and industrialised housebuilding (IHB) companies is low. The purpose of this research is to analyse the challenges faced when involving subcontractors in CI. To investigate the problem a two years case study has been conducted. The findings reveal that both conflicts of interest between main- and subcontractors and IHB practices combined with inherent structures, cause the challenges. A set of measures to overcome those is developed and proposed.

Keywords: continuous improvement, industrialised housebuilding, subcontractor involvement

Introduction

The involvement of employees within continuous improvement (CI) programs has become a common procedure within many industry sectors. The purpose is mostly to use their specific knowledge for incremental product and process improvements, as they are a rich source of knowledge within their area of responsibility (Abu El-Ella et al., 2013).

Within the industrialised housebuilding industry (IHB) a lot of construction-site working tasks are outsourced to subcontractors. These are mostly interior construction services such as electrical installation, plumbing, services for heating installation, screed work, plastering, among others. Subcontractors and their employees are, for this reason, an important source of knowledge enabling a continual improvement of the processes they perform, with a consequent enhancement of performance within the construction supply chain (Love et al., 2015).

In the case of subcontractors, their involvement in CI seems more challenging than those of direct employees as conflicts of interests between the IHB company and its subcontractors may exist (Love et al., 2016). These conflicts of interest are one explanation for the limited number of known examples of successfully involving subcontractors within CI programs (Söderholm, 2010). Consequently, there is little shared interest between IHB companies and subcontractors in collaborating in CI programs. Further reasons may be found in traditional structures and practices of the construction industry. However, the involvement of subcontractors in continually improving the supply chain performance remains beneficial, as they perform important construction services and can provide a lot of expert knowledge to on-site activities.

To improve business performance of their supply chains IHB companies should strive to integrate subcontractors within product and process improvement initiatives. Such collaborations may lead to more productive material and component usage, an improved coordination between on-site activities, with impacts on a reduction of failure frequency and construction lead time as well as an improved resource usage. Solutions for inter-disciplinary collaboration, to better use subcontractors' knowledge within CI programmes, are essential for the future of the IHB industry (Lessing et al., 2015).

This paper investigates the reasons for weak collaboration between IHB companies and their subcontractors in CI and suggests improvements, which have been developed during a two-year case study. Two research questions arise: (1) What are the key challenges for a successful implementation of CI within an IHB supply chain? (2) Which measures contribute to a better adaption of CI methodology to overcome identified challenges for subcontractor involvement within IHB industry?

This paper is organised as follows: The literature review analyses the current situation in IHB supply chain management (SCM) and provides an overview of relevant CI work in general as well as within the IHB literature. The material and method section presents the applied research process before the findings of the case study are shown. These findings include a causal loop diagram (CLD) to analyse the main impacts of stakeholders‘ activities on a CI program, an analysis of resulting key challenges, the developed measures and, finally, real-life data from the case study. Findings are discussed before finally conclusions are drawn.

Literature Review

CI by most definitions is a commitment to eliminate waste within systems and processes to increase the efficiency of an organisation in the long run (Abu El-Ella et al., 2013). It is embedded within a culture focusing on sustained performance enhancements through involving employees' specific knowledge of production processes within improvement activities (Bessant and Francis, 1999).

CI is not a single methodology. A number of tools, techniques, approaches and methodologies, dedicated to enable constant performance improvements, are included within its context. Best known methodologies are lean manufacturing, the balance score card, six sigma or hybrid methodologies of those (Bhuiyan and Baghel, 2005).

The difficulty with CI is that simply transferring it from one organisation to another is mostly not successful, as this cannot be a simple implementation of a tool for waste reduction. It relies on many soft factors such as learned routines and practices. For the successful implementation, such routines need to be adjusted to characteristics of a company and its supply chain (Bessant et al., 2001).

Despite the lack of an identical CI program, each CI program shows core abilities and key behaviours which develop over time. An important observation by Bessant and Caffyn (1997) was that CI maturity can be assessed on the base of existing core abilities and key behaviours. They assigned these to five levels of CI maturity. A higher CI-level shows more of these core abilities and key behaviours as well as an intensified problem-solving ability.

The development of these key behaviours and core abilities is supported by providing enablers e.g. procedures, companies' policies, resources, or structures. It is necessary to consider whether the characteristics of the company and its supply chain i.e. project orientation or a fragmented order fulfilment process, could complicate the provision of elaborated enablers and hinder the development of core abilities (Caffyn, 1999).

Construction supply chain management

Compared to manufacturing industries supply chain management is a very young discipline within construction management (Eriksson, 2010). This management concept aims to increase efficiency of supply chains through better planning and collaboration between supply chain participants. A prerequisite to this is an improved information flow between stakeholders (Vrijhoef and Koskela, 2000).

Common structures and practices

IHB industry, which is a part of the construction industry, has a unique situation when looking at management practices and structures. It has created new ways of building production and implemented many management concepts which are not found within traditional construction industries. Concurrently, it relies on many legacy structures and practices of the traditional construction industry (Höök and Stehn, 2008).

These common structures and practices hamper the implementation of proven management concepts and methodologies. Reasons may be both the inadequate adaption of such concepts as well as structures and practices within IHB industries. The most important ones will be found in the project based focus of order fulfilment (Ballard and Howell, 2003), the uniqueness of building projects, the fragmented IHB order fulfilment process (Knauseder et al., 2007), the different locations where activities are performed (e.g off-site and on-site) (Eriksson, 2010), to some extent the short term contracts between supply chain participants (Josephson and Saukkoriipi, 2007), and in inspection based rework of failure (Lundkvist et al., 2014). These traditional structures and practices with their inbuilt weaknesses produce an ineffective defect management regime (Lundkvist et al., 2014), weak knowledge sharing and at the least, weak participation of subcontractors within CI (Höök and Stehn, 2008).

In an investigation of the development of IHB industry, a case study of three Swedish IHB companies by Lessing et al. (2015), revealed similar areas of conflicts for the future management of IHB companies. But they also showed that long-term collaborations between IHB companies and their subcontractors became more common, which enhanced the importance of supply chain management in the field. The above mentioned requirements influence the implementation and development of CI.

CI application within IHB

Some previous publications covered the application of CI within IHB industry. Lessing (2006) described various management concepts including lean production, lean design or six sigma and their relevance for IHB. Söderholm (2010) investigated performance improvement through CI application within the design phase of industrialised buildings. Lessing et al. (2015) reported that CI concepts are used for improving repetitive activities in the prefabrication process. Meiling et al. (2014) demonstrated the applicability of a Plan-Do-Check-Act improvement process for the reduction of failure in an off-site and an on-site scenario. Already missing is an investigation into the challenges of successful integration of CI within an IHB supply chain. Such an investigation may help practitioners and scientists to better understand challenges arising and may help to find solutions for improving the performance of the entire IHB supply chain.

Material and Method

To investigate the reasons for weak subcontractors' participation and suggest improvements for CI methodology a two-year case study was conducted. The data was provided by an IHB company and its subcontractors. The applied research process is presented in figure 1. In a first phase, key elements within the CI methodology and their purpose are investigated through a literature review. Expert interviews and literature research revealed the current nature of IHB construction supply chain management. To analyse key challenges for implementing CI within an IHB supply chain, a causal loop diagram was developed which is based on a stakeholder analysis, interviews with IHB supply chain participants, and participating in observation. In a subsequent phase, adaptions of the CI methodology were iteratively developed and tested with participants of this specific construction supply chain. Twelve flagship building projects were scientifically examined over a 22-month period to develop and test the adaptions.

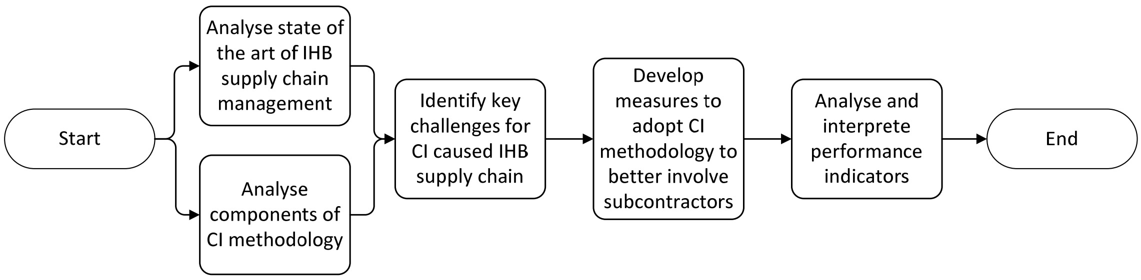

Figure 1 – Research process applied during the case study

The industrial partner of this case study focuses on entire order fulfilment from sales to handover of single- and two-family homes. It sells and builds around 200 single-family homes a year. According to Gibb (2001) the construction method can be defined as a mixture of non-volume and volumetric preassembly. To enable a full completion of the customers' order, many construction processes such as installation, plumbing, screed works, tilling, plastering, wall painting etc. are subcontracted within the supply network.

Identification of key challenges

From the established state of IHB supply chain management and CI application, key challenges for successful implementation of CI within an IHB supply chain were identified, as a first step, through a stakeholder analysis and an analysis of structures and practises. In a second step the results of the first analysis was used to develop a causal loop diagram to better understand the interrelations within the IHB supply chain and the effects when incorporating subcontractors in CI. Causal loop diagrams are a tool used in systems thinking to enable an assessment of participants behaviour within a system (Sterman, 2000). The CLD outcomes were verified in a third step through interviews with supply chain participants and participatory observation. The interviews and participatory observation served as a check to avoid false assumptions and enabled a deeper and stronger analysis of key challenges (Yin, 1994). This information was necessary for the iterative development of supplementary CI measures. Its consideration is essential for the promising integration of supply chain participants in continually improving products and processes and in reducing the risk of biased influence or unilateral preference of SC participants.

Development of measures to adapt CI methodology

After analysing the challenges, consideration was given to measures which might best overcome them. These were implemented. Measures which were found to be useful were further developed over time. Some further measures were incorporated and ineffective ones were eliminated. The development of measure complies with theory building through case studies (Eisenhardt, 1989; Yin, 1994) and was done on the base of participating observations and interviews.

Analysis of performance indicators

To assess the performance within the case study a selection of the lean indicators proposed by Martínez Sánchez and Pérez Pérez (2001) was applied. Data for performance indicators was used for both the initial and improved state. It was obtained in the year preceding the study and in its completion year. The performance indicators were used for the verification of the CLD.

Preliminary results

In this section a CLD analysis of key challenges is presented based on an investigation of the influences of common structures and practices within IHB industries as well as a stakeholder analysis. Upon these foundation improvements for applying CI methodology within an IHB supply chain are iteratively developed. The proposed improvements for CI methodology together with their rationale are described. Finally, performance indicators derived from the case are given.

Key challenges for implementing CI in an IHB supply chain

Stakeholder analysis revealed the variety of guiding principles under which they operate. Participants had various reasons and expectations for participating in the CI programme and making contributions.

The analysis of stakeholders reveals the conflicts between interests and expectations of different SC participants as well as their benefits. Both the IHB companies' top management and the subcontractors are interested in smooth cooperation during future projects. At a minimum they also seek successful coordination between main- and subcontractor processes, the processes between different subcontractors, as well as a willingness to collaborate in knowledge sharing to improve products and processes.

However, conflicts of interests between the stakeholders were found. Important conflicts were revealed around the topics of decision making authority and competence as well as influences on the development of standards and processes to gain competitive advantages.

Compared to the manufacturing industry, where the implementation of CI has been very successful, IHB industries differ in both practice and structure. These include:

- various activities for the fulfilment of orders are performed in different locations (e.g. design offices, production sites or different construction sites).
- a very complex product is designed and produced, which is mostly unique at the level of the building project. Despite this uniqueness there are similar activities undertaken during design and production.
- within the order fulfilment process building projects are mostly handled as a single project. For this reason, the order fulfilment process is more project than process oriented.

- defect management is traditionally based on inspection.
- the fulfilment of various working operations is done by a variety of a companies' departments and supply chain participants in a consecutive way. Due to the spatial distribution and temporal sequence of performing the activities, there is a lack of interdepartmental cooperation between supply chain participants.
- in some cases, short-term contracts between supply chain participants results in little interest in participating in improvement projects.

A consequence of these structures and practices is a low level of interest in sharing experiences for solving problems, which is analysed with a CLD. Problem solving for building projects mostly remains in the hands of supply chain participants e.g. subcontractors and will not be used for the long-term solution of problems.

To better understand above mentioned reasons and effects for weak involvement of subcontractors in CI programs a CLD was developed. This is shown in figure 2. The findings reveal that conflicts of interest, short-term contracts and implemented improvements with negative effects for subcontractors, have adverse effects on subcontractors' willingness to contribute to improvement ideas. The adverse effects for negatively implemented improvements can be mitigated if its reasons are well communicated to subcontractors. To the contrary, implemented improvements with positive effects on subcontractors raises their interest in participation, especially if the efficiency of subcontractor services is increased. This also stimulates the interest to participate in CI measures.

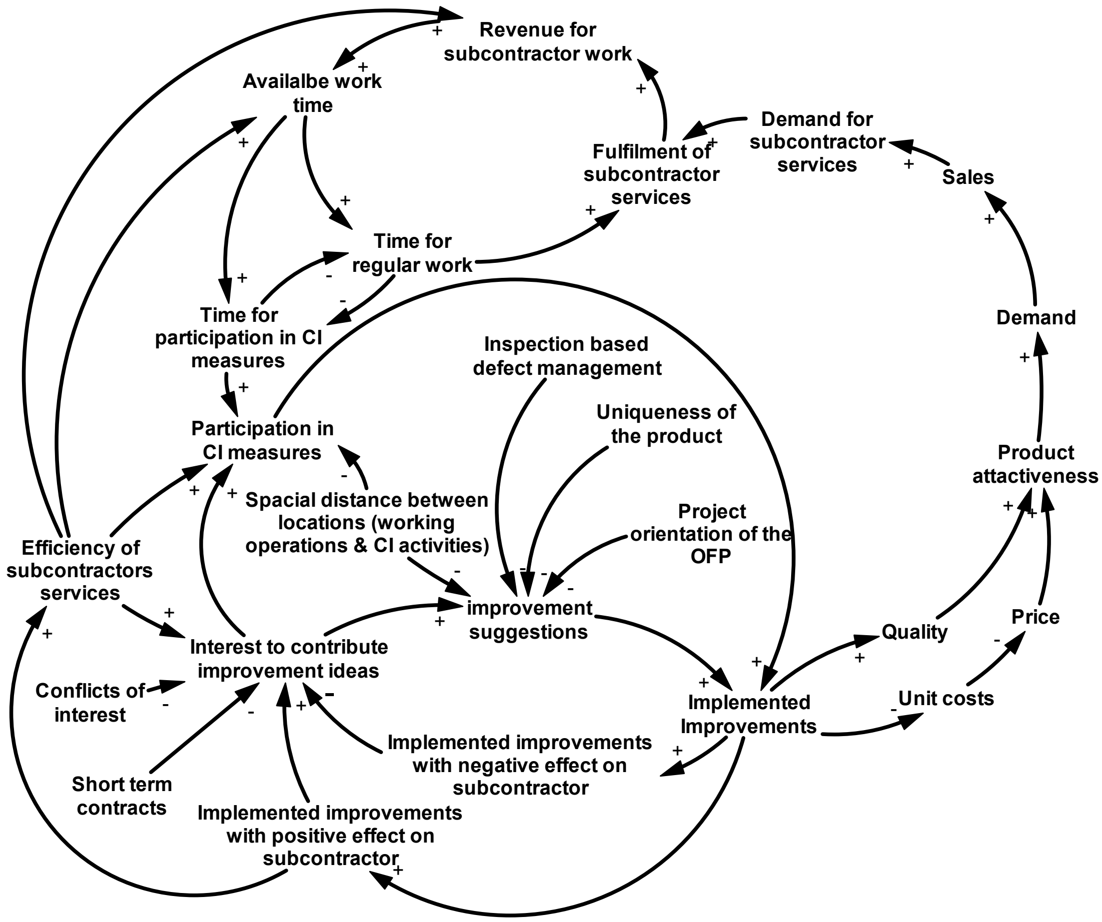

Figure 2 – CLD of impacts on CI in an IHB supply chain

Inspection based defect management, the uniqueness of building projects and the project orientation of the order fulfilment process is responsible for the weak contribution of improvement suggestions within the improvement program. In the case of inspection-based defect management it is often argued by subcontractors that problems are already communicated within the company. In reality, detected problems are only solved in this instant, the information is not used to eliminate the causes of the problem in the long run. The uniqueness of building projects and the project orientation also cause limited usage of improvement ideas within the CI program, as participants have the impression that everything is redesigned again for each project and a further use does not make sense.

An effect on both the participation within CI measures and the contribution of improvement ideas was revealed to be the spatial distances between the locations where activities for order fulfilment are performed. The spatial distance is a big barrier as people must travel to participate in improvement measures meetings. The contribution of improvement suggestions is also hindered, as the intercommunication of people on-site and in design offices is restricted.

The CLD analysis also revealed the conflict in balancing the available working time between contributing to CI measures and using it for the fulfilment of regular work. A further finding was that implemented improvements have impacts on the final product attractiveness, which increase the sales and raises the demand for subcontractor services. As a consequence, of subcontractors' participation in CI they can expect increased revenues. Reasons for the increase of revenues will be found in the improved efficiency of their services and an increase of orders from main contractor.

Measures to adapt CI methodology for IHB supply chains

To overcome identified challenges for subcontractor participation within CI, measures are iteratively developed. Those include:

- an involvement of subcontractors' employees in feedback channels and within suggestion schemes
- periodical flagship projects in order to test improvement potentials and to sensitise supply chain participants for process- and product improvements
- involvement within the preliminary and debriefing meetings of improvement projects, to discuss and develop improvements in this cross-functional teams
- long-term partnerships to strengthen the team spirit within the supply chain
- periodically inform supply chain participant to implemented improvements

Assessment of the program with PI

The adapted CI method is assessed with CI related performance indicators as presented in table 1. The analysis revealed improved subcontractor involvement within CI, an increase in the number of subcontractors' improvement suggestions per year, an increase of the percentage of implemented suggestions per year, as well as an increased involvement of subcontractors within improvement meetings and information systems.

Table 1 – CI related performance indicators

Performance Indicator	**Initial**	**Improved**
Number of total suggestions per year	27	42
Number of suggestions from subcontractors per year	3	17
Percentage of subcontractors' suggestions on total suggestions	11	40
Percentage of implemented suggestions	85	94
Number of people dedicated primarily to quality control	6	7
The frequency with which information is given to subcontractors	2	12
Meetings dedicated to knowledge sharing between employees from main- and subcontractor	0	18

Discussion

In recent years, CI has enabled impressive performance gains within manufacturing industries. Its implementation within IHB supply chains is not as successful. The reasons are probably due to the characteristics of IHB supply chains. To enable successful implementation in the future, the study reconsiders challenges to involve subcontractors and suggests appropriate measures to overcome the weaknesses.

Little sharing of experiences between supply chain participants was identified. Höök and Stehn (2008) and Eriksson (2010) revealed similar challenges for the knowledge sharing of on-site employees. This investigation revealed the causes to be the impact of different influences on the willingness to contribute improvement suggestions and the participation in improvement measures, as well as the opportunities to contribute improvement suggestions. These impacts will be identified in the inspection-based defect management regime, the project orientation of the order fulfilment process, the uniqueness of building projects, the distributed nature of the order fulfilment process and conflicts of interest between the IHB company and other supply chain participants.

To overcome this challenge periodical flagship projects are proposed. These serve to better involve subcontractors within CI programs, to sensitising them to contributing to improvement measures and enable the formation of cross-functional teams. The formation of cross-functional team is also in the line with Bessant and Caffyn (1997) who suggest this measure to reduce the lack of cooperation between divisions. Causes for weak cooperation associated to the inspection based defect management regime, the distributed nature of the order fulfilment and some conflicts of interest will be eliminated through cross-functional teams within the periodical flagship projects.

Additional important measures proposed were both to actively involve subcontractors in meetings related to improvement projects and within suggestion schemes. During these meetings it is possible to emphasis the process orientation of the building process to subcontractors. A higher contribution of improvement suggestions can consequently be expected.

Conflicts between the interests and expectations of different supply chain participants will probably appear. These should be balanced through the proper management of the CI program. It is important to consider that each stakeholder should get a fair reward for his / her contribution, otherwise the interest in participating within CI decrease.

One of the most important reasons to apply CI on the level of supply chain management is to incorporate the specific knowledge of subcontractors for performance enhancements. Subcontractors can probably contribute a lot of specific knowledge to the production process, which is difficult to acquire from the main contractors' viewpoint. To develop a holistic view of the building process and reduce the complexity

of it is also an important advantage gained from the involvement of subcontractors and their knowledge within CI.
This is suggested by Abu El-Ella et al. (2013). Bessant and Francis (1999) report the effects of employees' involvement and their various responsibilities along the order fulfilment process. The previously mentioned periodical flagship projects and the involvement of subcontractors in CI meetings contribute to a better analysis of complex problems and the joint development of solutions. A further important measure is long-term partnerships. Those contribute to a reduction of mistrust between supply chain participants and contribute to build a team spirit.
The analysis of CI related performance indicators obtained from the case study revealed improvements. Based on this data it can be assumed that applied adaptions of CI methodology help to overcome challenges for CI implementation within IHB industry.

Conclusion

Improving the productivity of the order fulfilment process through the involvement of subcontractors' knowledge is an important competitive factor for IHB companies. To gain such advantages, incremental innovation along the entire supply chain are essential, and IHB companies can benefit substantially from examples illustrating the successful implementation of CI within an existing construction supply chain.
To overcome the existing difficulties within CI the challenges for its implementation must be known. For this purpose, key challenges have been analysed with a review of literature, a stakeholder analysis, a CLD analysis, participating observation, and interviews with IHB supply chain participants. In particular, the CLD analysis helps to understand relationships within the IHB supply chain and their impact on CI programs. In the future, responsible managers will have the opportunity to set actions and measures more deliberately to improve the output of a CI program.
In a subsequent phase, adoptions of the CI methodology were iteratively developed with supply chain participants. Performance improvement through the application of the improved CI methodology with real-life data is presented. Evaluations of the applied adaptions, as they are presented here, may also help to implement appropriate measures. The applicability of CI methodology to reduce the reworking of non-conformities and to realise improvement potential within the entire supply chain is demonstrated. Additionally, potential efficiency enhancements are verified.
During this investigation a specific IHB supply chain was analysed. Even though it was chosen as a representative example of IHB supply chains in Central Europe, there is a need for further research to enable a broader applicability of findings. To contribute to the generalisation of findings, future work should include IHB companies and their construction supply chains focusing on other customer segments (e.g. multi-family homes), different construction methods (e.g. modular building or component manufacture and subassembly) as well as other geographic regions.

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