INTEGRATING STRATEGIC PROJECT SUPPLY CHAIN MEMBERS IN PRODUCTION PLANNING AND CONTROL

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ABSTRACT

Much of the waste in the construction industry is related to ineffective planning, including design delays, flaws in the planning system and ineffective integration of suppliers in the planning system. Although SCM literature suggested some opportunities regarding the integration between construction supply chain (SC) firms and pointed out the difficulty of identifying critical SC members, so far no previous research has proposed mechanisms for identifying and integrating strategic project supply chain members. This research study proposes a set of guidelines for integrating supply management functions through the production planning and control system as well as using it for understanding the main problems related to the lack of integration. Multiple case studies were carried out in a main contractor from the South of Brazil. In those case studies a set of criteria was defined for choosing strategic suppliers and some improvements in the production planning and control were implemented. Among the main conclusions of the study, this research work proposes a strategy to identify the SC members that have to be integrated into a typical construction project and manage them across the Last Planner System®.

KEY WORDS

Lean supply chain, Supply chain management, Integration, Last Planner System

INTRODUCTION

In recent years, there have been several research efforts focusing on how to improve the management of construction supply chains. These studies have revealed that the management and integration among participants in a supply chain reduces individual risks and has the potential to improve the efficiency of the production process as a whole, eliminating waste and unnecessary efforts (O'Brien, 1999; Vrijhoef and Koskela, 1999; 2000; O'Brien et al., 2002; Vrijhoef et al., 2003).

According to Ballou et al. (2000), the SC comprises the integration and coordination of activities and processes throughout the chain member companies. Christopher (1999) points out that trust, commitment and willingness to share information among the members of the chain are very important for the functioning of the SC as a set of interconnected processes. The integration among participants reduces individual risks and has the potential to improve the efficiency of the production process as a whole, eliminating waste and unnecessary efforts (Christopher, 1999).

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Some authors (Cox et al., 2000; Cox and Ireland, 2002) state that construction firms are gradually turning to the use of external suppliers for construction related services, which were previously supplied internally. As a result, supplier management is an increasingly important concern in the construction industry. Therefore, in order to maximize the business value of construction products and services, an effective supplier management strategy has become a critical component (Cox and Ireland, 2002).

However, according to O'Brien (1999), the construction sector has been moving slowly towards the application of SCM, partly due to the peculiarities of this industrial context. In many construction projects, there is a lack of integration of the construction company and its suppliers. SC integration in a project should include several processes, such as material supply, operations design, production planning, and site installation.

Previous research (Ballard, 2000; Koskela, 2000; Ballard et al., 2002) indicates that the Last Planner System® can play a key role in the integration of construction companies and their suppliers in the management of project supply chains. Hence, this paper proposes that the integration of construction companies and their suppliers should be achieved by involving the strategic suppliers in the implementation of the lean principles and techniques that are encrypted in the Last Planner System®, such as pulling production, reducing variability and increasing flow reliability. The primary way for achieving this objective is to integrate supply management functions through the production planning and control system. This strategy incorporates the application of a conceptual framework for SCM (Lambert et al., 1998) for inter-firm integration and management, and the implementation of the Last Planner System® for production control (Ballard, 2000).

This paper presents the main results of a M.Sc. dissertation (Sterzi, 2006), which aimed to propose guidelines for integrating strategic supply chain members in production planning and control. This research work was based on three case studies carried out in a building company from the State of Rio Grande do Sul, South of Brazil. This firm was considered to be the focal company of the project SC.

In the following item a brief literature review is presented, emphasizing the conceptual framework for SCM proposed by Lambert and Cooper (2000) that was adopted in the study. Then, the research method is described, followed by the presentation of the main results of the study, which were structured according to the proposed guidelines.

SUPPLY CHAIN MANAGEMENT

The literature about SCM is characterised by a number of different interpretations and definitions for supply chain and its related activities, each one of them often overlapping with or contradicting the others (Tan, 2001; Ross, 1998).

SCM was originated in industries where demand is predictable, requirements for variety are low, and volume is high (Christopher, 2000). In the construction industry, however, the nature of organization is essentially temporary, the products are one-of-a-kind, and production is mostly on-site and characterized by high levels of complexity (Vrijhoef et al., 2003; Bertelsen and Koskela, 2004). Construction supply chains have remained fragmented and highly adversarial because of the conflicting nature of demand and supply (Isatto, 2005).

Each project has different needs and constraints that need to be understood so that the appropriate sourcing strategies can be developed for the specific products and services to

be delivered. The understanding of power structures at each stage of SC depends on the identification of the criticality of the product and service for the end customer and the nature of demand and supply (Cox and Ireland, 2002).

Lambert and Cooper (2000) describe the interrelated nature of SCM by using three elements (Figure 1): (a) the SC network structure (who are the key SC members that should be considered?); (b) the SC business processes (what processes should be considered in the link between key SC members?); and (c) the SCM components (what level of integration and management should be applied for each process link?).

The basic idea of the SC network structure is to recognize the interdependency among SC members and, thereby, improve its configuration and control based on factors such as: integration of business processes, joint planning, physical and information flows management and channel leadership (Cooper and Ellram, 1993; Lambert and Cooper, 2000). However, it is difficult to predict the exact number of the supply chain members that have to be integrated into a typical project.

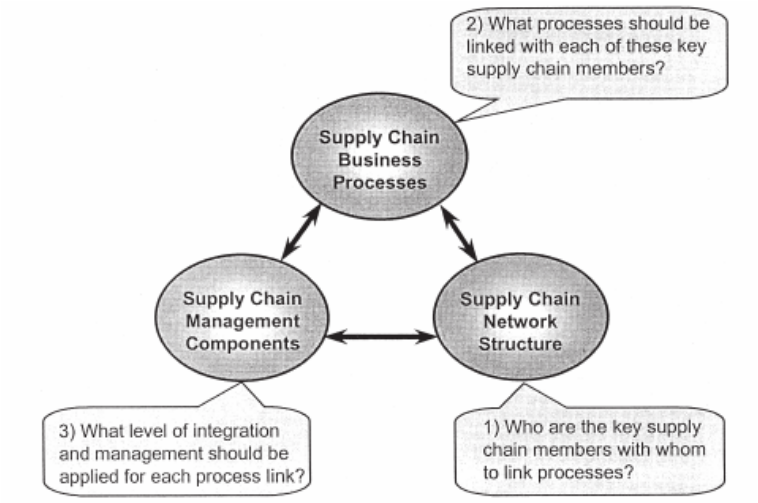

Figure 1: Supply chain management framework: elements and key decisions (from Lambert and Cooper, 2000)

Lambert and Cooper (2000) illustrate a generic focal company SC structure network (Figure 2). Within the generic SC, the construction firms often play the key role of integrating many upstream SC members (Cox and Ireland, 2002). For that reason these companies are often considered as the focal company when analyzing a supply chain. However, managing all tier-1 suppliers' networks to the point of origin is an enormous undertaking. Managing the entire supply chain is a very difficult and challenging task (Lambert and Cooper, 2000).

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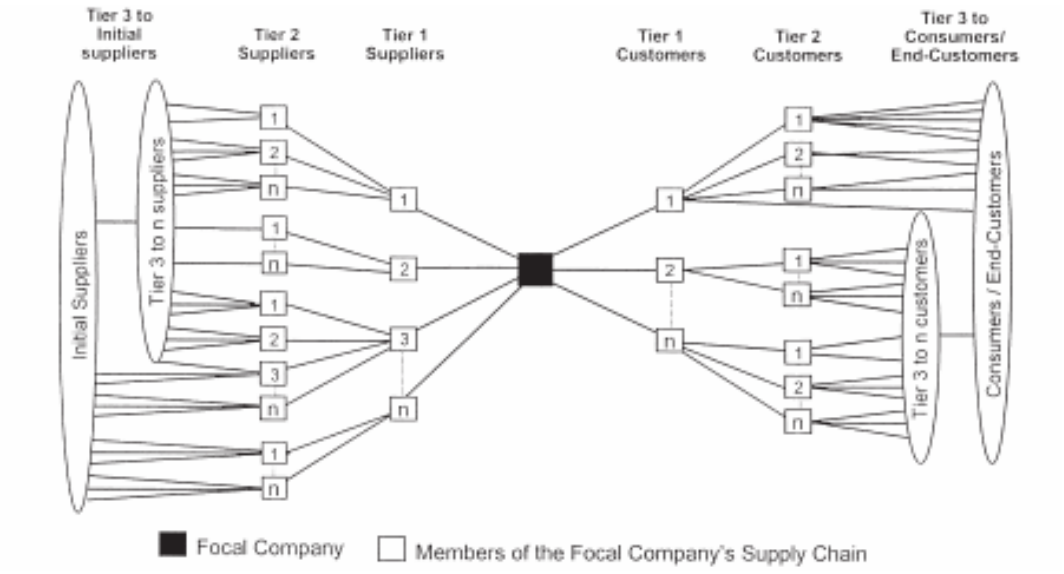

Figure 2: Generic focal company SC structure network (from Lambert and Cooper, 2000)

Therefore, this research work concentrates attention in the strategic project SC members, also named as key SC members (Lambert and Cooper, 2000) or critical members (Cox and Ireland, 2002), which are able to: (a) conduct business in an honest and open manner; (b) focus on needs and expectations of customers; (c) operate a program of continual improvement; (d) measure performance and set targets for continuous improvement; (e) exchange information – benchmarking; (f) work within a total team concept; and (g) work in an ethical and sustainable manner.

RESEARCH METHOD

The main contractor involved in this research study was a medium size company, which in general carries out industrial and commercial building projects for private clients. Most projects are renovations or extensions in existing buildings where the client facilities need to operate continuously. These projects typically have a relatively short duration – most of them up to six months, and a very high level of uncertainty, mostly due to the interference from the client in the production process, and the need for product flexibility. These characteristics make their projects very complex, demanding a reliable production planning and control system. In fact, this company has a well developed planning and control system which is strongly based in the Last Planner System®.

The research study was divided into three main phases. The first phase consisted of an exploratory investigation aiming to understand the current involvement of the suppliers in production planning and control, as well as to collect the perceptions of key managers on the problems that existed in terms of integration between the main contractor and its suppliers. Phase 2 involved the development of two case studies in which some changes were introduced in the main contractor production planning and control, aiming to increase the level of participation of key suppliers in that process. Finally, the third phase involved the analysis of data, from the final interviews (after the implementation) as well as from the planning and control plans. Table 1 presents a brief description of the case studies.

Table 1: Overview of case studies

	Case Study 1	**Case Study 2**	**Case Study 3**
Description of the project	Construction and refurbishment of an industrial building for a steel manufacturing company	Construction of an industrial building for a car manufacturer	Construction and refurbishment of an industrial building for a car manufacturer
Description of the study	Identification of problems related to the lack of integration of the supply chain.	Implementation of changes in the production planning and control systems in order to improve the level of integration of suppliers	Implementation of the SCM framework and improvements at the level of integration
Objective	Exploration of the differences between the participants' production systems	Application of the SCM conceptual framework in the focal company during one construction project	Improvement the level of integration trough the SCM in the focal company during a second construction project
Method	Direct observation technical visits	Participant observation, planning and control system operation and focused interviews	Participant observation, planning and control system operation and focused interviews

In the first phase, four managers of the case study company were interviewed: the commercial director, the commercial manager, the planning and production manager and a site engineer. All of them played key roles in the management of project supply chains and also in production planning and control. The first case study was also developed in this phase. Initially, a selection of the key suppliers in this project was made. These were: foundations, steel frame fabrication an assembly, pre-cast concrete fabrication and assembly, representing the tier-1 suppliers for this project. The site managers of those suppliers were interviewed, in order to obtain their perspective on the problems affecting production planning and control. The interviews lasted from one to one and a half hour. The production management systems of the main contractor and subcontractors were also examined throughout direct observation of planning and control meetings, analysis of production plans and control reports, and performance measures.

Based on the problems identified in the first phase of the research, some changes were proposed on the way the project supply chain were managed: (a) definition of criteria for choosing strategic suppliers, (b) changes in the production planning and control system, (c) training strategic suppliers´ employees before work started on site. The overall aim of phase two was to test the effectiveness of some changes in the production planning and control system of the main contractor.

Both case studies 2 and 3 followed the same steps (a) identification the SC strategic members; (b) identification of the necessary changes in the production planning and control system; (c) training sessions for the strategic suppliers; (4) implementations of changes in the production planning and control; and (5) evaluation of the level of integration of suppliers in the production planning and control system.

The main sources of data used in the Stage 2 were: participant observation in production planning and control meetings; feedback from meetings and training sessions involving representatives of SC strategic suppliers; analysis of production plans and performance measures (PPC and the causes for the non-completion of work packages); semi-structured interviews with six representatives of strategic suppliers.

A check-list of production planning and control good practices was used to assess whether the planning and control practices have been fully or partially adopted by the suppliers. This evaluation was based on the semi-structured interviews as well as on the

participant observation in production planning and control meetings. Descriptive statistical variables as well of qualitative data were used to assess the impact of the changes introduced in the planning and control system in the level of integration of the project supply chain and in planning reliability.

DISCUSSION AND RESULTS

The choice of supply chain strategic members

When determining the network structure, it is necessary to identify who the strategic members of the SC are. Those strategic suppliers should receive more managerial attention and resources than others. Lambert and Cooper (2000) suggest the use of a set of criteria for selecting the key SC members, although these criteria may vary depending on the focal company purposes.

Cox and Ireland (2002) suggest some criteria to classify the SC participants such as product impact, complexity and degree of interdependence. Those criteria were tested in the first case study and subsequently refined in case studies 2 and 3. In each case study the criteria was jointly defined by the members of the project management team. The final set of criteria established for the focal company was: project cost impact, product quality impact, lead time impact, technological complexity of the sub-system, and degree of interdependence with other SC members.

The strategic supply chain members for each project were defined in a meeting, involving the company top managers and also production managers. Those suppliers were defined as those companies or businesses that had a high impact on all criteria. This resulted in a supply base reduction and a focus on the following suppliers in case studies 2 and 3: steel frame fabrication an assembly, pre-cast concrete fabrication and assembly, water and sewage installation systems, electrical installation systems and sprinklers fire installation systems.

The supply chain business processes vs. Last Planner

Integrating and managing all business process links throughout the entire SC may cause the network to become too complex (Lambert and Cooper, 2000; Cox and Ireland, 2002). For that reason, a decision was made to identify a small number of process links that had a key importance in the integration of production management systems between the main contractor and the strategic suppliers.

Three components of the production planning and control process were chosen as the key project supply chain process links to be managed: (a) short-term planning, (b) look-ahead planning and (c) analysis of physical flows.

Considering the importance of improving those process links, some improvements were made in the production planning and control system in both case studies 2 and 3: planning and control process standardization, process analysis, effective implementation of constraint analysis, use of visual devices, increasing consistency on the use of performances indicators, planning and controlling physical flows. Figure 3 shows and example of a physical flow plan that was produced in case study 2.

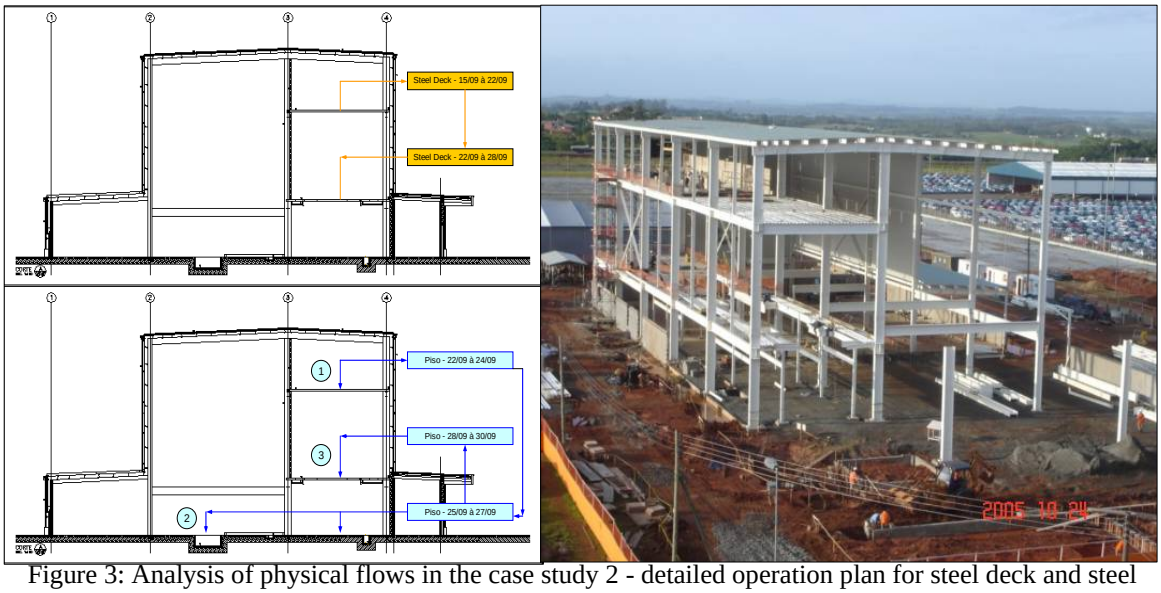

Figure 3: Analysis of physical flows in the case study 2 - detailed operation plan for steel deck and steel frame activities

Those improvements in the production planning and control system as well as the training that was provided to all suppliers had a positive impact in flow reliability and production throughput in both case studies. Figure 4 shows the improvement in PPC (percentage of plans completed) that was obtained after the implementation of the integration measures (from stage A to B). This kind of result indicates the important role that the Last Planner System® may have as a mechanism for improving supply chain integration in the short term.

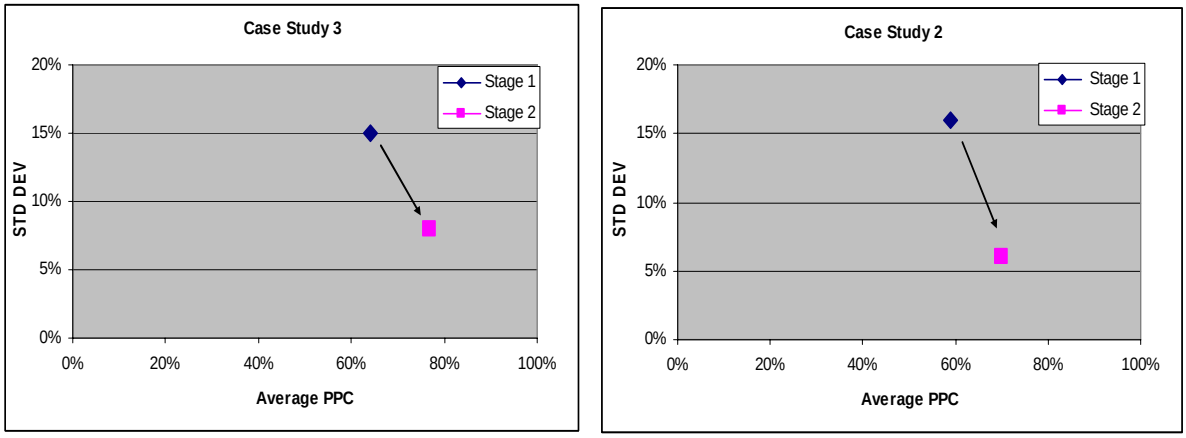

Figure 4: Average PPC and PPC standard deviation in case studies 2 and 3 before (stage 1) and after (stage 2) the improvements

SCM components: level of integration vs. planning and control practices

During this research study, the connection between the six managerial components proposed by Lambert and Cooper (2000) was explored, nominally the physical and technical components (planning and control, work structure, organization structure; product flow facility structure, information flow structure), and the components of the production planning and control (short-term planning, look-ahead planning and analysis of physical flows). These six components have demonstrated a clear similarity with the Last Planner System®.

For example, in case study 3, the focal company had integrated one strategic supplier to the lookahead planning process by applying the following physical and technical components: planning and control, work structure and information flow structure. However, the managerial and behavioural components (management methods, power and leadership structure, risk and reward structure and culture and attitude) in general were less well-understood, and more difficulties were found in their connection.

The level of integration of strategic suppliers to the focal company production planning system was evaluated in the case studies using two performance indicators: (a) PPC; and (b) the implementation efficacy (Table 2).

The implementation efficacy indicator was obtained through a checklist of fourteen production planning and control good practices. A subjective assessment is made on whether they have been fully or partially implemented by the supplier. These practices attempt to make more explicit some of the underlying ideas of the production planning system. They are fully described by Bernardes and Formoso (2002). The evaluation was carried out through the semi-structured interviews and also by participant observation at the construction sites, both at the beginning of the case studies and after the planning and control improvements were implemented.

The strategy adopted for integrating suppliers to production planning systems had a strong influence on the application of these practices. For instance, short-term planning was usually the first stage of implementation. For that reason, some integration practices related to that short-term planning level were implemented more intensively than other practices. The practices that were implemented by the strategic suppliers at the end of the research study did not have the same degree of success. This is the case of practices # 3, #5, and #11 (Table 2).

Some practices had not been effectively integrated by any of the firms involved in the case studies (practices #9 and #10). This can be explained mainly by the fact that some supplier managers did not perceive the utility of such practices. This indicates that it is necessary to give more emphasis to them during the training sessions. Simulations and practical examples also may help.

Despite the problems related to the implementation of practices # 9 and 10, in general the integration process was reasonably successful in most suppliers. Based on Table 2 and the Figure 4, it is possible to observe that there is a clear trend of improving both the PPC and the implementation efficacy. The combined analysis of both indicators may provide some evidence on whether the production planning and control system have been effectively integrated.

Table 2: Implementation of production planning and control practices by the strategic suppliers

Legend: P – Previous Evaluation CS2 – Case study 2 CS3- Case study 3	**Strategic Suppliers**										
	A		**B**			**C**		**D**		**E**	
PRACTICES	**P**	**CS2**	**P**	**CS2**	**CS3**	**P**	**CS2**	**P**	**CS2**	**P**	**CS3**
1. Standardization of planning and control process	0	0.5	0.5	1.0	1.0	0	0	0.5	0.5	0.5	1
2. Establish planning and control hierarchies	0.5	0.5	0.5	0.5	1.0	0	0.5	0	0	0	0.5
3. Analysis and qualitative evaluation of processes	0.5	0.5	0	0.5	0.5	0	0	0	0	0.5	1
4. Analysis of physical flows	0.5	0.5	0.5	0.5	1.0	0.5	0.5	0.5	0.5	0	0.5
5. Constraint analysis	0	0.5	0	0.5	1.0	0	0	0	0	0	0.5
6. Use of visual devices	0.5	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7. Formalization of short term planning	0	1.0	0	1.0	1.0	0	0.5	0.5	1	0	0.5
8. Detailed specification of tasks	0	0.5	0	0.5	1.0	0	0.5	0	0.5	0	0.5
9. Programming of workable backlog	0	0.0	0	0	0.5	0	0	0	0	0	0

10. Shared decision making	0	0.5	0.5	0.5	0.5	0	0	0	0	0.5	0.5
11. Use of PPC and identification of the causes of problems	0	0.5	0	0.5	1.0	0	0	0	0	0	0.5
12. Use of performances indicators	0	0.5	0	0	0.5	0	0	0.5	0.5	0.5	1
13. Corrective actions based on the causes of problems	0	0	0	0.5	0.5	0	0.5		0.5	0.5	0.5
14. Meetings for information diffusion	0	0.5	0	0.5	1.0	0	0.5	0.5	0.5	0.5	0.5
TOTAL	2.0	7.0	2.5	7.0	11	1	3.5	3	4.5	3,5	8
Effectiveness of implementation	**14%**	**50%**	**18%**	**50%**	**79%**	**7%**	**25%**	**21%**	**32%**	**25%**	**57%**
Supplier Average PPC for the project	-	**73%**	-	**76%**	**79%**	-	**62%**	-	**69%**	-	**82%**

Notes: Weight 1.0 – fully implemented ; Weight 0.5 – partially implemented; Weight 0.0 – not implemented

Reviewing the production and planning practices

Based on the analyses of the results obtained in the Case Studies, some changes on the check-list of good practices were proposed, in order to make clear the expectations of the main contractor with the participation of the strategic suppliers in the production planning and control system. Table 3 presents the new set of thirteen practices. This set of practices may be used to assess the degree of integration of those participants in this process.

Table 3: The new set of good production planning and control practices for strategic suppliers

	Practices
1	Supplier Planning and control process standardization and formalization
2	Commitment in the Production system design meetings
3	Alignment with the long term planning goals
4	Adherence to the project execution strategy
5	Adequate definition of the capacity of production resources
6	Preparatory lookahead planning tasks
7	Lookahead planning meetings commitment
8	Constraint analysis commitment
9	Preparatory short term planning tasks
10	Short term planning commitment
11	Alignment with the short term planning goals
12	Corrective actions based on planning performance indicators
13	Shared decision making and information diffusion

CONCLUSIONS

SCM may be approached as the development of techniques and tools which enable a firm or a group of firms to gain a competitive advantage. In reality, it deals with integration and managerial improvement of the whole supply chain through a close collaboration between the focal company with suppliers.

This study has explored some opportunities for improvement by the interpretation of the SCM conceptual framework across the Last Planner System®. Integrating supply chain members in the production planning system involves the design and management of a process that goes beyond the focal company boundaries. The introduction of formal methods may prevent managerial problems, such as: ineffective information flows, lack of cooperation, poor coordination and insufficient role definition of the SC agents. Regarding the production planning and control on site, the benefits of stabilizing the

production process were obtained as SCM concepts were more effectively implemented. If the production system is not reliable, suppliers cannot effectively plan on-site delivery of materials, or coordinate its work-teams.

This paper proposes a quite simple way to identify the supply chain members that have to be integrated into a typical construction project, manage them across the Last Planner System®, and evaluate their level of integration by the effectiveness of production planning and control system implementation, using a number of practices that can be related to production management core concepts and principles. This research suggests that it is necessary to establish effective mechanisms for coordinating activities between supply chain members in order to integrate activities across such firms. Future work should address the need to identify systematic mechanisms to provide feedback among supply chain members, in order to improve the performance of the supply chain as a whole.

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