A LOGISTICS FRAMEWORK FOR IMPROVING CONSTRUCTION SUPPLY CHAIN PERFORMANCE

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In recent years, attention has been placed on the logistics activities in construction projects in order to reduce total costs. The construction industry is experiencing poor productivity, resulting from an inability of contractors, subcontractors, and suppliers to cooperate efficiently. Research on logistics in construction lacks a holistic perspective and tends to focus on one activity at a time. This research presents the Builder's SCOR model (BSCOR) to be used for logistics improvements in construction. The model is based on the Supply Chain Operations Reference Model (SCOR model) covering the total supply chain. The BSCOR model is empirically derived through five case studies at different construction sites over a period of five years. This has resulted in a model covering the activities Source, Build, and Plan, that describes the flow of materials to and on the site and how ownership passes to the client. With the BSCOR model, contractors can map the material and information flows between supply chain members with standardized process definitions. It is also possible to precisely measure the supply chain performance and to know where to put improvements efforts. The main intention with the BSCOR model is to help the industry reduce costs and increase productivity.

Keywords: construction control, construction logistic, measurement, scor, scm.

INTRODUCTION

Many researchers have for a long time pointed out potential problems in the construction industry, leading to an increase in the construction cost and a decrease in the construction productivity demonstrated by Vrijhoef and Koskela (2000). For example, Laufer and Tucker (1987) and Gidado (2004) stress the deficiencies in planning as a potential cause. In general terms they blame the cost-increase and production problems on a lack of understanding of the role of planning. Other authors such as Latham (1994) and Egan (1998) conclude that the current situation stems from an inadequate way of managing suppliers and subcontractors. If the planning problems, the obsolete supply chain management, and overuse of temporary organisations are not managed they can, according to Fearne and Fowler (2006), not only affect the costs and productivity but also propagate and affect the construction project performance in total.

In this paper, the problems (planning deficiencies and supply chain management issues) are not seen as two isolated areas that should be mitigated solitarily; instead, the problems are dealt with in conjunction. As Cheng et al. (2010) emphasize in their

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report, many of the existing construction problems (such as planning problems, temporary supply chains, bad performance, etc.) can be eased if greater attention is put on developing a logistics framework for mapping, measuring, and continuously learning from each construction project. Authors such as Bassioni et al. (2005) and Wegelius-Lehtonen (2001) share this view, that a logistics framework can be helpful in order to reap the benefits from better-managed supply chains. The problem with current frameworks, except from being few, is that they tend to focus on one part of the chain and not the complete chain from raw material to finished house (e.g. Wegelius-Lehtonen 2001), or that they are entirely based on existent models developed for other industries without adjusting them to construction contexts (e.g. Cheng et al. 2010). In 2009 a workshop was conducted at a Swedish construction company, presented in Johansson and Persson (2011), in order to identify potential improvement areas (like a need for standardised processes and performance assessment). Except from identifying problems it also conclude that implementing a construction adapted version of the Supply Chain Operations Reference model (SCOR), see (SCC 2013) and section "Developing a Construction Logistics Framework" for more information, can have a positive effect in overcoming many of the problems and to increase the construction performance.

The purpose with the project, reported in this paper, is to fulfil the adaptation of the SCOR model to the characteristics of the construction industry, according to suggestions made by Johansson and Persson (2011), and thereby develop the Builder´s SCOR model (BSCOR). In order to fulfil the purpose the research objective is to identify which parts of the SCOR model that have to be adapted to embrace the characteristics of the acquisition (procurement of materials), construction, and planning processes in the construction industry.

The paper is organised as follows. In order to position the project, section two presents a literature review addressing common problems in the industry. Section three briefly describes the research method applied in this project and what data gathering methods that were used. After describing the method, section four will describe the SCOR model and the work with adapting the model and motivate why the adaptations are deemed necessary. Discussion of potential benefits and deficiencies with the model and the project will be held in section five whilst section six aims to show that the research objective has been fulfilled and present the managerial and research implications with this work.

CONSTRUCTION LOGISTICS ISSUES

The seminal works by Latham (1994) and Egan (1998) demonstrate that the construction industry is in a worrying situation with e.g. decreasing productivity. This is recognised by Vrijhoef and Koskela (2000) who show decreasing productivity and increasing costs in the Finnish and Dutch construction industries. However, they also state that the problems often emerge earlier on in the supply chain and propagate to the construction site. Why the productivity is declining is debatable, but Fearne and Fowler (2006) suggest that the fragmented and temporary nature of the construction industry supply chain is to blame. This view is shared by many authors in the research field (e.g. Fernie and Thorpe 2007), like the view that a proper use of supply chain management (SCM) principles can mitigate the effects of the problems. Vidalakis et al. (2011), for example, suggest that the builders' merchants should receive greater influence in the management of the supply chain, as they possess a natural linkage between the suppliers and the contractors. However, it is questionable how costefficient that might be, as Voordijk (2010) corroborates, an extra node in the supply chain will increase the total cost. It might also lead to a potential risk for experiencing the bullwhip effect when an extra node in the chain is added. Dainty et al. (2001) on the other hand reports on a belief from the subcontractors that the client should take greater responsibility in managing the supply chain. The problem then however is the risk that members who have never worked together feel forced into a new constellation with increasing mistrust and unwillingness to cooperate as results.

Whether to handover the SCM process to the builders' merchant or to the client, the coordination issue is of great importance for the industry. Except from a lack in coordinating supply chains, many authors report a lack in supply chain performance measurement (Wegelius-Lehtonen 2001). Existing literature on performance measurement in construction often focuses on construction project performance and overlooks the importance of measuring the whole supply chain, including the suppliers. This can be exemplified by Bassioni et al. (2005) and Wegelius-Lehtonen (2001) who both emphasize project performance (quality, cost and time aspects) as an important aspect to assess. The view of a lack from the academia in performance measurement of the whole supply chain is also shared by Cheng, et al. (2010), like the absence of performance measurement and logistics frameworks. If members of the supply chain fail to cooperate or other SCM related problems are not remedied they can have a significant effect on the on-site logistics performance. Voigtmann and Bargstädt (2010), for example, identified that a lack of systems thinking results in an increase in the amount of inventory-holding areas on-site. Re-planning the location of these inventory-holding areas (and the movement of material) results in an increased production cost.

Planning the construction project and supply chain is often tainted with problems, which are often divided based on if they stem from the pre-construction or the on-site planning process (Johansen and Wilson 2006). The pre-construction planning process consists of selection of project team; creation of the project documentation system; initiating the purchasing of materials; development of the schedule and milestones; and other pre-project-execution activities; while the on-site planning process consists of more operational activities and focuses on: ensuring that planned activities can be fulfilled; schedule adherence; material procurement; weekly meetings; etc. Laufer and Tucker (1987) pinpoint the fact that much of the literature focuses on the on-site planning process and mostly on the scheduling activity techniques. However, one should not see pre-construction and on-site planning as two isolated processes as the on-site activities are affected by the decisions made during the pre-construction phase (Johansen and Wilson 2006, Laufer and Tucker 1987). Much of the problems reported in the literature regard the lack of sharing information, lack of including supply chain members, not planning resources, and that too great deal of focus is put on planning-technicalities. Gidado (2004), for example, recognises that including subcontractors and suppliers in the planning process is an important factor for performance success. Exclusions might lead to dysfunctional information flows and problems in learning from each other and each project.

RESEARCH DESIGN AND METHOD

The work with adapting the SCOR model started in early 2008 by applying it to a construction project. Outcomes indicated that the model had to be adapted to the industry. In late 2008 a project at another Swedish construction company verified the need for adaptation. The actual adjustment of the model started in 2010, where the delivery of material process from suppliers to construction site and the procurement (of construction materials) process on-site were analysed and adapted. Two cases in 2012 initiated the work with adapting the production and planning processes. In total five cases over a four-year period were studied. The cases were selected according to three criteria: the projects should be in the framework supplement phase; the budgeted cost should be in the interval of €1–10 million; and the sites should be within geographical proximity for the researchers.

The main method utilised in this study is Case Study Research (cf Yin 2009), and the main data gathering methods used are direct observations and semi-structured interviews with focus on identifying necessary adaptations to the SCOR model. Direct observations made it possible to see what changes deemed necessary. Validation of the observations was performed through interviewing site managers and supervisors, to get their opinions on the suggested changes. By observing the reality as it is, and determine how the model should be developed according to the craftsmen themselves, makes the model adapted to construction industry settings and easier for the construction companies to adopt. Validation of the model as such has been an iterative process, where findings and adaptations from the previous cases have been validated in next coming cases (to see if the changes are deemed necessary in this case too). For example, the deemed changes to the process of procuring construction materials are validated in the case where the changes to the construction process are suggested. A test and validation of the whole model is scheduled as a future research project.

Reasons for choosing the SCOR model as an initial model are threefold: it is proven fruitful for improving profit margins in manufacturing industries (Bolstroff and Rosenbaum 2007); it is well-recognised in other industries and encompasses well-defined definitions of metrics and processes; and the authors are well-trained in the model. Using Case Study Research allows the researcher to observe the phenomenon in its natural setting (Yin 200). This is of importance in this project.

DEVELOPING A CONSTRUCTION LOGISTICS FRAMEWORK

The SCOR model was first released in 1996, developed by two consultant companies to fill the need for a structured supply chain analysis tool (SCC 2013). The model is today maintained by the non-profit organisation Supply Chain Council (SCC). It is used as a reference model for supply chain improvement and consists of three parts: a business process reengineering tool comprising a set of predefined supply chain processes; a set of predefined metrics; and a set of identified best practices.

The SCOR model's supply chain processes consist of six generic process types: Source, Make, Deliver, Plan, Return, and Enable at the highest aggregated level (1), see Figure 1 (the Enable process is not presented as a separate process in the figure). These processes are given more details and meaning in level 2, where processes are distinguished between types of production: make-to-stock, make-to-order, or engineer-to-order type of production. In level 3, the activities in each level 2 process are listed. All level 1, 2 and 3 processes and activities are defined in the SCOR model.

The predefined metrics are used to measure the state of a supply chain and to benchmark it against other chains in the same industry. The metrics in the SCOR model are defined in three levels (not to be confused with the three levels of processes), and the metrics at different levels are structured so that a level 1 metric is an aggregated value of several level 2 metrics. SCC also runs a benchmark database for members of the council.

With the business process-reengineering tool, predefined processes are used to map the as-is and desired to-be states of the supply chain. This mapping, together with the benchmark analysis, results in knowledge where supply chain improvements are necessary. The SCOR model provides a list of best practices for each process that needs to be improved. How this improvement can be achieved depends on the supply chain structure and position, but help can be found in the list of best practices coupled to each process provided by SCC. Originally the SCOR model was developed for manufacturing but there has been an interest among researchers and practitioners to adapt the model to other industries. In di Martinelly et al. (2009) the model is adapted to a healthcare setting and in Legnani (2011) the after-sales service was in focus. It is evident, when analysing the two previous mentioned reports, that their models are adapted with a deductive approach. First, the necessary process are adapted and verified empirically later on. This should be compared with the inductive approach proposed in this paper, where empirical evidence is first collected for justifying necessary changes. These initiatives show that the SCOR model can be adapted e.g. by adding new processes, metrics, and best practices to better fit other industries or activities than manufacturing.

The work with adapting the SCOR model to capture the characteristics of the acquisition, production, handover, and planning processes in the construction industry started with two pilot studies where the SCOR model was used to map and measure the performance of construction supply chains. The results from the pilots were promising but it was evident that the SCOR model was not adapted to a construction setting. This was mostly noticed when studying the process of delivering material to the site and how material was received at the site. The SCOR model basically takes a lot of things for granted, such as a sheltered environment and ready resources for unloading of incoming transports.

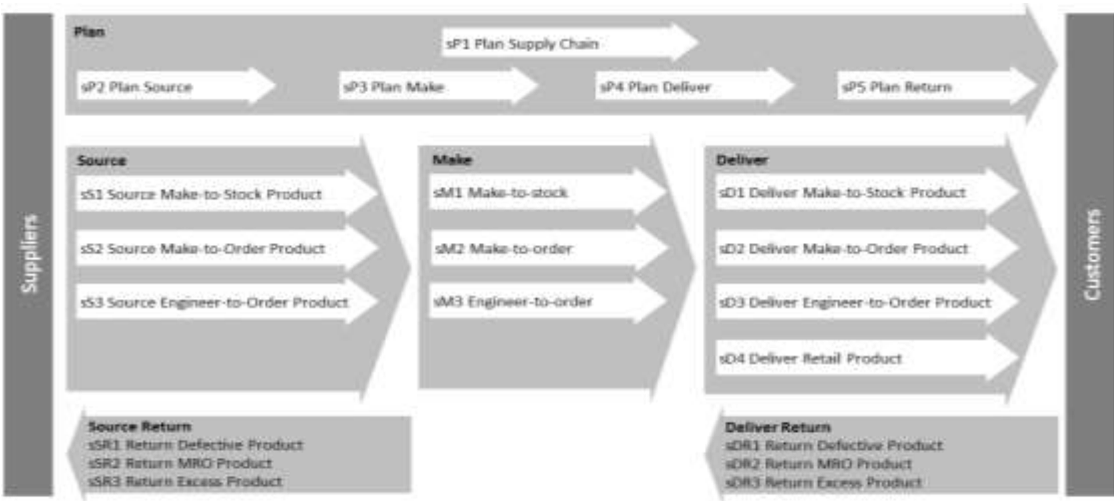

Figure 3: The SCOR model with level 1 and 2 processes, prefixed with 's'.

The first step to adapt the SCOR model to construction settings was to closer examine the Deliver and Source processes. As reported in Persson and Thunberg (2012) the Deliver processes at the suppliers were investigated together with the corresponding Source process at the construction site. In Thunberg and Persson (2013) the Make process at the construction site was studied. This study also led to the examination of the Plan process as reported in Thunberg et al. (2013). The Deliver process where the finished building is handed over to the client and the Return processes are not yet fully examined.

The result of the work to adapt the SCOR model to a construction industry setting is called the Builder's SCOR model (BSCOR). The BSCOR model retains the basic structure of the SCOR model and keep all the processes and metrics from the SCOR model intact but adds new processes and metrics where needed. This way, the BSCOR model can be used to map the supply chain from suppliers of construction materials to and on the actual construction site. The rest of the supply chain, upstream from the suppliers, is still best modelled with the SCOR model.

In level 1, the main flow of material is modelled by Builder's Deliver from the supplier and Builder's Source at the construction site. On the construction site, Builder's Build (Make), Handover (Deliver to the client), Return, and Plan can be used for modelling construction work, the handover process, returns, and the planning processes, see Figure 2.

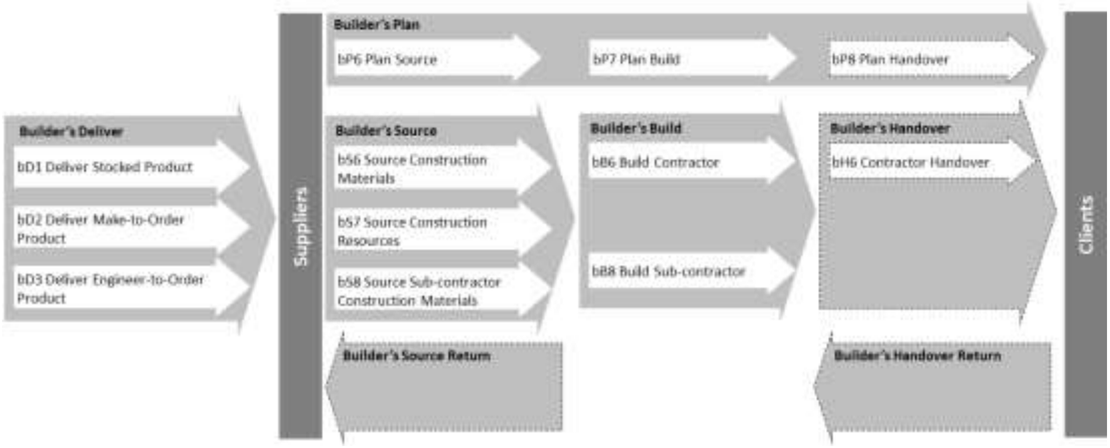

Figure 4: The BSCOR model with level 1 and 2 processes, prefixed with 'b'.

The BSCOR model is created based on two basic principles. First, the material flow is divided into two separate flows depending on who ordered the construction material; the contractor or the subcontractors. The contractor has the whole picture of the project and of the site itself and plans deliveries based on that knowledge. The subcontractors lack the comprehensive view and see only to their part of the project. In Persson and Thunberg (2012) it was clear that this separation of material flows caused problems with deliveries at the site with trucks forced to share unloading areas and waiting for their turn for resources used for unloading such as wheel loaders. In the BSCOR model, the two material flows are kept separated in order to identify the flows and thereby highlight the need for coordination. The second principle is the identification of deliveries of temporary materials that are used for a period of time and then returned. Typically, scaffolding is such a material that is used on-site, stored on-site, and returned after the project is completed. In the BSCOR model, this type of delivery is called a delivery of resources since also wheel loaders and cranes belong to this material type.

Planning on the construction site in the BSCOR model is made in the processes Plan Source (bP6), Plan Build (bP7), and Plan Handover (bP8). These processes, as reported in Thunberg et al. (2013), establish a plan based on the demand for material (or resources depending on the process) and the supply of material (or resources). This is done for both contractor and subcontractors. Then, all these plans are coordinated in a master plan for the whole construction site.

Considering the material flow in BSCOR, the scope starts at the suppliers and ends up on the site. At the supplier, the Deliver process keeps the original division between make-to-stock, make-to-order, and engineer-to-order products as suggested by the SCOR model. Alterations are made in level 3 of these processes to better follow the suggested Builder's Source processes. The metric that control performance in Deliver is Perfect Order Fulfilment. In BSCOR, a new level 2 metric is incorporated in Perfect Order Fulfilment that measures if a shipment is notified in a proper manner or not. If a shipment is late and the site is unaware of the delay, resources for unloading are reserved for unnecessary amounts of time.

The BSCOR model divide the Source processes in level 2 into three types based on the above mentioned principles. The Source process in level 2 is therefore divided into Source construction materials (bS6) where the contractor source material, Source construction resources (bS7) where the contractor rent resources like crane, scaffolding, and wheel loaders for shorter periods of time, and Source Subcontractor construction materials (bS8) where subcontractors source their own materials, see Persson and Thunberg (2012). These three different types of sourcing processes are often not coordinated at the construction site. The division is made to clearly differentiate between these three types of processes and to make it possible to highlight the need for coordination.

The Builder's Build process is the actual process of erecting a building. Also here, the material flow principle of dividing material usage by contractor and subcontractors is valid. The Plan process has the same coordination problem and creates a master plan for the whole construction site. In the Build process at level 2 both Build contractor (bB6) and Build subcontractor (bB8) are using the material brought there from the Source process. Metrics in the Build process focuses on the logistics of the construction site. That is why a new metric is introduced that measures the number of movements of construction materials at the site. Material should be unloaded on site and transferred to its inventory-holding area and then moved to the place of use. All other movements, if the material is obstructing work or has a high risk of damage, are considered unnecessary.

The Enable, Return, and Handover processes have been left out of the empirical studies made so far. The final definitions of these processes are part of future research. Considering the Return processes, very little evidence has been found to support their existence. Waste is being shipped to special companies that recycle or use the material for fuel in combined power and heating plants. Resources that are rented are being returned to the renting companies. This does not correspond to the definition of Return in the SCOR model, where returns are made of defective, MRO (Maintenance Repair and Overhaul), and excess material. None of these types of returns have been found in any of the construction projects so far. The Handover process has been found to hold very little of logistic activities and is here treated as a simple transfer of ownership from contractor to client.

DISCUSSION

A potential benefit with the BSCOR model is that it offers a structured model for mapping and measuring construction supply chain performance, from suppliers' supplier to customers' customer. Among others, the Plan process specifically pinpoints how subcontractors and their acquisition and production plans should be integrated. The lack of supply chain performance measurement and the coordination issue were identified in the literature section as potential causes for the cost increase.

The BSCOR model in its nature is a normative model developed according to best-case scenarios. Even so, the model also contains some descriptive elements, as the SCOR model in its origin form does. For example, the balancing of production plans among supply chain members is clearly a normative element since this balancing is not done to date and is believed to be of benefit to increase project performance. Also the addition of a notification process in delivery and the associated level 2 metric in the Perfect Order Fulfilment metric, are results of the normative nature of the BSCOR model. The lack of notification is deemed as a problem and should thus be highlighted in the model. Even if the need for notification could be seen as a result of poor communication and lack of trust between suppliers and the main contractor, which should not be highlighted as best case scenario, the notification should be included in order to overcome these problems. The BSCOR model has not been fully tested yet, even if the findings from each case have been tested in succeeding cases. The final test of the model is scheduled as a future project.

Another matter worth discussing is the potential difficulties when implementing the model in the industry and who should lead the work with implementing it. Would it be easy to implement such a structured model in an industry characterised by temporary organisations and fragmented supply chains? Probably not, but that is not a reason for not promoting such a structured model. The problem lies in how the model is promoted and how the work with implementing it is conducted. Regarding implementation, who should lead the overall work with implementing SCM principles? Some authors (cf Dainty et al. 2001) report that many members in the supply chain think that the client should take greater responsibility in this work. However, it is postulated here that the main contractor, as a natural linkage among all members in the supply chains, possesses the greatest potential to effectively manage the supply chain and integrate all its actors. One issue with implementing the model that practitioners might highlight as a problem is the lack of comparable data in the benchmarking tool in the BSCOR model's infancy. Understandably, the lack of comparison data in the outset of a benchmarking tool is salient. Once again, this is an issue of significance when promoting the model and the participating companies must be aware of the situation.

Before concluding this discussion it is worth mentioning the problems encountered during the project. Of biggest concern were (1) the attitude among some of the craftsmen and managers and (2) the availability of documentation. The former could be related to the previous discussion of implementation difficulties. Some managers and craftsmen are happy with how it is now and do not want to change this autonomous nature in the industry. However, the majority of the craftsmen and managers considered the development of the model as important and that the current situation in the field is not of advantageous for anyone. The latter one is a result of not having a standardised system for tracking documentation. Most of the information is saved in the mind of the manager, inaccessible to others. The lack of documentation systems can hamper the implementation of a measurement system.

CONCLUSIONS

The purpose with this study was to present a logistics framework adapted to the characteristics of the construction industry that encompasses the most relevant parts of the construction supply chain. This is fulfilled through the development of the construction adapted and SCOR (Supply Chain Operations Reference model) based Builder's Supply Chain Operations Reference model (BSCOR) presented in this paper. Logistic frameworks proposed elsewhere in the literature (cf Cheng et al. 2010) often forget to embrace the settings in the industry and the authors suggest that models developed for manufacturing settings are also applicable to construction industries. The risk of not considering contextual differences when promoting improvements is highlighted by Johansson and Persson (2011), who suggest that the models have to be adapted accordingly.

In summary, the BSCOR model starts at the supplier and the Deliver processes are adapted to better fit the way construction materials are delivered. At the construction site, the Source processes are divided into three categories depending on if the materials are ordered by the contractor or by the subcontractors, or if the materials are rented and used for a while and then returned. In the Build processes, the BSCOR model distinguishes between activities done by the contractor and by the subcontractor. This is utilized in the Plan process, which highlights the need to coordinate contractor and subcontractor activities on the site. The Handover process is a simple transfer of ownership and the Return processes handle returns of construction materials.

The practical contribution with this model is a tool for mapping construction supply chains and measuring supply chain performance. By mapping the supply chain problem areas can be detected and acted upon. Vrijhoef and Koskela (2000) identify that problems often arise early in the supply chain while their effects are not seen until later on the construction site. The BSCOR model also offers the construction companies a possibility to assess the problems' effect through a standardised measurement system. If several problem areas are identified the BSCOR model can assist in identifying which problem area that potentially has the biggest effect on overall supply chain performance. In line with the discussion of Vrijhoef and Koskela (2000) about problems propagating to the site, focusing on improving upstream supply chain logistics can have a positive impact on the down stream on-site logistics too. This structured model, used in a logistically unstructured environment, helps the construction companies to start learning from project to project. By mapping the processes and identify problem areas these can be mitigated to the next project. The contribution to the academia is a logistics framework developed to embrace the characteristics of the construction industry, which is missing in the literature to date.

Future work contains to test and validate the model but also to include the return, handover, and enable processes in the model. Even if each constituting part of the model is created through an inductive approach and validated iteratively, the entire model in itself is not tested and validated. This has to be done in order to verify that the model actually do mitigate common problems presented in the literature. Except from that, more attention in the future should be put on to develop construction supply chain metrics, best practices, and how the model should be implemented.

REFERENCES

Bassioni, H A, Price, A D F and Hassan, T M (2005) Building a Conceptual Framework for Measuring Business Performance in Construction: An Empirical Evaluation. "Construction Management and Economics", 23(5), 495-507.

Bolstroff, P and Rosenbaum, R (2007) "Supply Chain Excellence – a Handbook for Dramatic Improvement Using the Scor Model". 2ed. New York: Amacom.

BSCOR (2012) Retrieved 26 April, 2012, from www.bscor.com

Cheng, J C P, Law, K H, Bjornsson, H, Jones, A and Sriram, R D (2010) Modeling and Monitoring of Construction Supply Chains. "Advanced Engineering Informatics", 24(4), 435-455.

Dainty, A R J, Briscoe, G H and Millett, S J (2001) Subcontractor Perspectives on Supply Chain Alliances. "Construction Management and Economics", 19(8), 841-848.

di Martinelly, C, Riane, F and Guinet, A (2009) A Porter-Scor Modelling Approach for the Hospital Supply Chain. "International Journal of Logistics Systems and Management", 5(3), 436-456.

Egan, J (1998) "Rethinking Construction". London: Department of the Environment, Transport and the Regions.

Fearne, A and Fowler, N (2006) Efficiency versus Effectiveness in Construction Supply Chains: The Dangers of “Lean” Thinking in Isolation. "Supply Chain Management: An International Journal", 11(4), 283-287.

Fernie, S and Thorpe, A (2007) Exploring Change in Construction: Supply Chain Management. "Engineering, Construction and Architectural Management", 14(4), 319-333.

Gidado, K (2004) Enhancing the Prime Contractor's Pre-Construction Planning. "Journal of Construction Research ", 5(1), 87-106.

Johansen, E and Wilson, B (2006) Investigating First Planning in Construction. "Construction Management and Economics", 24(12), 1305-1314.

Johansson, M and Persson, F (2011) Towards a Scor-Based Analysis Tool for Construction Management and Logistics. In: Persson, F and Rudberg, M (Eds.), "PLANs FoT-konferens 2011", 31 September 2011, Norrköping Sweden.

Latham, M (1994) "Constructing the Team". London: HMSO.

Laufer, A and Tucker, R L (1987) Is Construction Project Planning Really Doing Its Job? A Critical Examination of Focus, Role and Process. "Construction Management and Economics", 5(3), 243-266.

Legnani, E (2011) "Controlling and Improving the Provision of after-Sales Services", PhD Thesis, Universtà Degli Studi di Bergamo, Bergamo.

Persson, F and Thunberg, M (2012) Adapting the Scor Model to the Construction Industry Settings. In: Töyli, J et al. (Eds.), "24th NOFOMA 2012", 7-8 June, Turku, Finland.

SCC (2013) Retrieved 21st of March, 2013, from http://www.supply-chain.org

Thunberg, M, Persson, F and Rudberg, M (2013) Coordinated Supply Chain Planning in Construction. To be presented at the "7th Nordic Conference on Construction Economics and Organisation", 12-14 June 2013, Trondheim, Norway.

Wegelius-Lehtonen, T (2001) Performance Measurement in Construction Logistics. "International Journal of Production Economics", 69, 107-116.

Vidalakis, C, Tookey, J E and Sommerville, J (2011) The Logistics of Construction Supply Chains: The Builders' Merchant Perspective. "Engineering Construction & Architectural Management", 18(1), 66-81.

Voigtmann, J and Bargstädt, H (2010) Construction Logistics Planning by Simulation. In: Johansson, B et al (Eds.), "2010 Winter Simulation Conference".

Voordijk, H (2010) Physical Distribution Costs in Construction Supply Chains: A Systems Approach. "International Journal of Logistics Systems and Management", 7(4), 456-471.

Vrijhoef, R and Koskela, L (2000) The Four Roles of Supply Chain Management in Construction. "European Journal of Purchasing and Supply Management", 6, 169-178.

Yin, K R (2009) "Case Study Research: Design and Methods". 4th ed. London: Sage.