The potential of information sharing to improve supply chain performance in construction projects

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Abstract
The purpose is to explore the potential of increased supply chain performance by improved information sharing between suppliers and contractors in the construction supply chains. Six suppliers are included, representing different combinations of supplying materials and tools for the product or services to support production as well as few or continuous deliveries during the project. The study show that suppliers need different information sharing practices if they continuously present at site or have few deliveries. Based on this and information sharing literature, we have developed a model of what information different suppliers need, including how and when to exchange it.

Keywords: Information sharing, planning and construction industry

Introduction
The supply chains in construction (CSC) are often complicated because construction projects demand a multitude of materials and resources from many different types of suppliers. These materials and resources needs to be delivered on-time, to the correct site and per rules set by site management and to make this work is a complex task (Thunberg and Persson, 2014). There are several authors highlighting the low supply chain performance in construction (e.g. Vrijhoef and Koskela, 2000; Thunberg and Persson, 2014) and the many supply chain related problems, i.e. supplier and subcontractor exclusion in the planning process, lack of information sharing among supply chain members, and lack of trust (Thunberg and Fredriksson, 2018). These problems can jeopardise construction project performance in terms of time and cost overruns (Atkinson, 1999). Operational supply chain performance can be seen as; product quality, speed, dependability, flexibility, and cost (Slack *et al.*, 2001). Thunberg and Fredriksson (2018) show that there is a link between supply chain related problems and supply chain planning and coordination. Tserng *et al.* (2006) conclude that the supply chain and its planning and coordination are often left aside in construction. For example, in a literature review Seppänen and Peltokorpi (2016) identify that earlier research have focused on performance in terms of delivery reliability, whereas less attention have been given the relationship between coordination of deliveries with suppliers and productivity of the construction workers. If supply chain planning and coordination is to work, information has to be shared. The importance of information sharing is further underlined due to of the many and widely different actors in construction projects (Adriaanse *et al.*, 2004). Thus, there is a need to explore the relationship between the supply chain performance of

a project and the information sharing in its supply chain. Therefore, the purpose of this paper is to explore the potential of increased supply chain performance by improved information sharing between suppliers and contractors in CSC. The findings of the paper are to be summarize into a model (based on Figure 1) of what type information different types of suppliers need to take part of and how this can improve their supply chain performance.

The study is conducted from the perspective of the suppliers and it is their potential of increased supply chain performance that is studied. Although many authors suggest the importance of understanding the entire scope of the supply chain in construction, it is often still perceived as the contractors supply chain (London and Kenley, 2001). For example, according to Akintoye (1995) it is obvious that JIT material management must be controlled by the contractor and it is them who should communicate this to their suppliers. Though, it is not only the contractors that suffer from poor supply chain performance, also the suppliers are affected through e.g. resource inefficiency. Therefore, there is a need to develop research about project and firm level view of CSC and explore the explicit interfirm supply chain coordination on projects (London and Kenley, 2001), which this paper intends to contribute to.

Theoretical framework

Construction is characterized by complex communication and coordination environments involving a large number of individuals and interacting functions or actors, and the assembly of many components, varying from low-cost like nails to high-cost like steel beams (Akintoye, 1995). Construction in general is produced on a project basis in temporary organisations, which leads to temporary supply chains, where each construction site requires a new logistics setup as the location is unique (Dubois and Gadde, 2000). Already in 2002 Dubois and Gadde described the CSC as decoupled. More recent reports from e.g. McKinsey (2017) confirms that this is still true. Because of the loose couplings in the CSC, knowledge and information sharing is decreased (Bygballe and Ingemansson, 2014), leading to coordination challenges (Thunberg and Fredriksson, 2018). The CSC consist of many types of suppliers; material suppliers, equipment suppliers, subcontractors and specialists (Proverbs and Holt, 2000) as well as different types of service providers.

It is important to note that many suppliers are part of numerous supply chains, and have a network of multiple customers and relationships that need to be managed simultaneously (Christopher, 2011). Because of the temporariness and well-documented fragmentation of construction, suppliers often make available what they believe the contractor and client want (Proverbs and Holst, 2000). However, this guess is not always based on actual information from the contractor.

Typically, the many suppliers conduct their own planning, but the responsibility to plan and coordinate the CSC and construction site as a whole still resides with the contractor (Azambuja and O´Brien, 2009). However, Fellows (2009) describes that coordination is most often absent in construction projects. In a literature review, Aloini *et al.* (2012) show that two of the most cited problems in construction are inadequate communication and late involvement of CSC members. There is thus a lack of information sharing and coordination in the CSC (Thunberg and Fredriksson, 2018). Apparently, the contractor faces the challenge of managing a network of multiple supply chains delivering different materials, products, and resources to the construction site. Proverbs and Holt (2000) suggest a two-way information/knowledge flow to improve the responsiveness of the CSC to meet the clients demands for economic construction. In the same way that early contractor involvement can improve project constructability, a more

"permanent" involvement of suppliers in project delivery can provide opportunity for them to offer their expertise and to maximize potential for cost savings (Proverbs and Holst, 2000). Such an integration converts the suppliers from suppliers of mere "product" to providers of a "service".

Seppänen and Peltokorpi (2016) identify in a literature review that there are conflicting goals between actors in the CSC. The contractors wish for JIT supply in small batches, whereas the building suppliers such as merchants aim to deliver full trucks and minimized distances and MTO producers would like to keep their setup costs down and therefore produce in large batches. The lack of coordination, lack of information sharing, and conflicting goals in the supply results in poor CSC performance. For example, in construction projects, as much as 60-80 % of the gross work involve materials and services purchased from suppliers and subcontractors (Scholman, 1997). Handling and logistics costs can furthermore be as high as 250 % of the materials procurement price according to Vrijhoef and Koskela (2000). Thunberg and Persson (2014) also highlight the poor delivery service in the construction industry, indicating that less than 40 % of deliveries are flawless.

Mohr and Nevin (1990) defined four facets of communication or information sharing. The amount of communication is referred to as the **frequency** and/or duration of contact between organizational members. **Direction** refers to the vertical and horizontal movement of communication within the organizational hierarchy. The medium of communication, or its **modality**, refers to the method used to transmit info whereas **content** of communication refers to the message that is transmitted. Fawcett et al. (2007) showed that willingness to share information has a somewhat stronger influence on operational performance than connectivity/modality.

The shared information should be relevant and meaningful (Kaipia and Hartiala, 2006) i.e. only information of high quality that improve supply chain performance should be shared. Too much information leads to "noise" that distorts or hides the intended information (Weaver, 1949). Information quality is defined in terms of timeliness, accuracy, relevance and added value according to Wiengarten et al. (2010). Furthermore, previous research presumes that shared information is actually used (Jonsson and Myrelid, 2016). Though, this is not always the case, it depends on the receiver's willingness and ability (Jonsson and Myrelid, 2016). Previous studies in other industries have shown that communication in order to share information improves supply chain performance. These studies have however mainly focused on the benefits of the OEM to transfer POS-data to their suppliers, though with exceptions (e.g. Jonsson and Myrelid, 2016). This paper follows more the line of Jonsson and Myrelid, taking the suppliers point of view were forecast and planning information is more relevant than POS (in line with proposition 5 by Kaipia and Hartiala (2006) stating that [the OEM should] understand suppliers' real needs for demand information). In construction instead of POS data, suppliers' real need of information can be current inventory levels and progress in relation to project time plan as project planning in construction should coordinate the work between participants, i.e. that all participants share the same view of the project goals (Fellows, 2009). The procurement and material plans are dependent on the project plan (Zwikael, 2009). These need to be developed early in the project (Johansen and Wilson, 2006) as effective planning should ensure that all involved actors know what to do, when to do it, and whether the required resources are available, e.g. what the off-site conditions might be (Murphy, 2013) affecting delivery options. Furthermore, delivery and handling of construction materials must be coordinated with site resources.

Methodology and empirical summary

To fulfil the purpose of the paper, a multi-methods approach is adopted.

First, a conceptual framework describing different types of supplier scenarios was developed (Figure 1), which was used for selection of illustrative cases. According to Akintoye (1995) some suppliers will have continuous deliveries to the construction site, and some will have few deliveries during a project, depending on the type of materials supplied. Due to the delivery pattern the suppliers will have different types of contact with the site management and thereby ability to know the progress of the project, i.e. different level of coordination and information. Furthermore, a construction project not only requires materials, there are also services supporting the production (Akintoye, 1995). The provision of integrated solution of service and product has an impact on the supplier-buyer relationships (Bastl *et al.*, 2010). Based on this, we differentiate between materials and tools for the project and services that supports the production. We also differentiate between few or continuous deliveries to site, see Figure 1.

The purpose of analytical conceptual research is to add new insights into traditional problems through logical relationship building. These studies usually employ case study examples to *illustrate* these conceptualizations (Wacker, 1998, pp. 373, 378). Empirical illustrations are thus provided for the four conceptually identified scenarios. Here we have used purposive sampling in order to represent all four identified scenarios (Williamson, 2002, p. 32). The appropriate illustrations were identified based on meta-analysis of our own previous research projects and complemented with interviews conducted specifically for this study. In line with Lacoste and Johnsen (2015) we have thus used 'tacit knowledge' gained through immersion in the field to guide both our document study approach as well as the selection of illustrative cases.

	Materials and tools for product	Services to support production
Continuous supply during the project	Suppliers A and C	Supplier E
Few deliveries during the project	Suppliers D and F	Supplier B

Figure 1 – Scenarios for suppliers to a construction project

Interview protocol

The following questions were asked to all six suppliers:

1. How is the supply set up?
   a. Who is the customer?
   b. What do you supply?
   c. How do you deliver?
2. How do you plan the deliveries?
   a. What information do you need? When do you need it?
   b. How is your supply chain performance?
   c. Is this affected by the (lack of) information you receive?
3. What information do you receive from the customers?
4. Do you actively try to improve the information that you are given and what else (regarding information sharing) do you do to improve your performance?

Empirical summary

The data in Table 1 has been collected with structured interviews, following the interview protocol, which was developed based on the theoretical framework.

Table 1 – Summary of empirical data, based on interviews

Supplier A	Supplier B	Supplier C	Supplier D	Supplier E	Supplier F
Customer					
Contractor	Developer	Contractor	Developer	Contractor	Subcontractor
What is supplied					
Expenditure items; such as clothes, tools and concrete pipes.	Inspection services for construction works	Tools and infra-structure to projects.	Handmade customized wooden front doors.	Waste management services.	Indoor and outdoor lighting fittings
Supply chain setup					
Uses a structure of a central and local or regional DCs and stores. From the central DC there is 24 hrs delivery time to whole of Sweden.	For small projects, a local inspector is used. For complex projects, the inspector is selected nationally and based on specific competencies.	Delivers from local depots with milk runs. Small customers usually come and pick their products up at the depots.	The doors are shipped directly from the factory to constructions all over Sweden.	Have recycling establishment close to Stockholm and Gothenburg. Brings containers to and collects them from the construction sites.	For smaller projects one delivery whereas larger projects can have scheduled deliveries over several years.
Deliveries					
Need information about contact person and project specific delivery conditions. For larger projects 3 weeks ahead to secure supply. Rescheduling is accepted 48 hours before delivery. The customers have been spoiled by ordering the night before.	An inspection should be ordered 6 weeks in advance. The documents should include everything from the initial order, modifications and protocols from construction meetings. Often the availability of the inspector dictates the schedule.	Do not really feel that they need any specific information. Like to have the information 24 hrs before delivery but they can deliver within a couple of hours. The start-up meeting should preferably be a month ahead of project start.	The front door should be the last thing that is installed in order to minimize damages. Deliveries are thus often squeezed between the last subcontractor delivery and final inspection. Time from order to delivery varies between years to a few weeks.	Like to know site setup and area to plan containers. Different phases of the construction bring different types of waste. Since they are present on site it is relatively easy to capture changes. Need orders 24 hrs in advance, otherwise emergency pick-ups.	Deliveries are planned based on customer demand. Larger projects have dictated slot-times for delivery. Smaller projects have wider time windows for delivery. Standard products are delivered from stock, customized products within 14 days.

Information supplied					
Try to have start-up meetings with larger projects. Sellers uses a checklist. In general contractors are lousy at sharing information. Though, when customers see that we are interested they get more willing to share as well.	The construction documents are provided by the customer. A big problem is changes that have been agreed on without written proof. If all information is not available, the end-product will be less reliable.	Use pro-active project surveillance. Have a start-up meeting to know the phases of the project. Thereafter the customer centre follows the project and call and check. They would like the customers to share project plan	The delivery date is set by a centralized purchasing function. Delivery performance is measured towards this date even if the site supervisor wants the door earlier/later in order to fit to the progression of the construction.	Like to have start-up meetings with the project. If they are invited early they can affect the location of the waste areas on the ground as well as on the floors, it gives the possibility to show the advantages of Recycling assistance.	Need updates about installation schedule. Now they might expedite a prio-order with use of overtime and weekend work, just to find that the project is delayed. This information might be available at the sales department
Information improvement/needed					
To go from supplying only products to services. VMI services, kitting, removal of wrapping. Decreases problems of customer's employees ordering the wrong products. Deliveries without physical receiver. Improving labels and improve customer interface for online ordering including planning services.	There are official lists of what documents that should be shared with the inspector. If the right information with correct quality is provided in time, we can deliver with high performance.	Today they know resource utilisation, but not when and how. They also would like to start delivering more services, be a more integrated part of the customer's value chain. Together with A, they have something called the kitchen wagon, were C supply the tools and A supply the nuts and bolts needed.	Would like to be involved earlier to provide feedback. The tendering could reflect a product that cannot be built. Information sharing means that ALL documentation is included, and ALL changes are pushed to ALL suppliers. This creates information overload.	Try to sell more services. If they are allowed to be on site with their own personnel, the level of recycling is increased and the knowledge and understanding of what the customer needs. Based on the problems discovered, such as low recycling levels, they can adapt services.	For standard orders deliveries are calculated with ATP available-to-promise. For customer adaptions the delivery time is dependent on the adaptions and if materials are in stock or not (might require the identification of a completely new supplier).

The empirical data, summarized in Table 1 have been complemented with background information about the case companies. Data have been gathered through semi-structured interviews, workshops and focus groups during a time period of 3 years as part of three different research projects. The analysis was first a within case analysis to see how each supplier acts and thereafter the suppliers were compared between the categories of Figure 1 for pattern matching (see Figure 2).

Analysis and discussion

The purpose of this paper is to explore the potential of increased supply chain performance by improved information sharing between suppliers and contractors in the CSC. Six suppliers to the construction industry have been studied. Figure 2 below shows the identified patterns between the suppliers and categories of the interview guide seen in Table 1.

	Materials and tools for the product (A, C, D, F)	Services to support production (B, E)
Continuous supply during the project (A, C, E)	Contractors customers Delivers from local depots/warehouses 1-2 days from order to delivery Local sellers communicating with site management Continuously present at site Start-up meetings to improve service Focus on delivery conditions and what products from a wide assortment to deliver and services to support products C needs updates on project time plan and production phases	Contractors customers Delivers from local establishment 1-2 days from order to delivery Local sellers communicating with site management Continuously present at site Start-up meetings to improve service and to know production phases Focus on delivery conditions and what services can be added to support production at site
Few deliveries during the project (B, D, E)	Developer/subcontractors customers Delivers from factory Weeks to months from order to delivery National sellers communicating with national purchasers Would like to be involved in the design process to improve service and products Need updates on project time plan to know when to deliver	Developers customers Nationally based National sellers Information supplied controlled by national laws Delivery set by project time plan

Figure 2 – The deliveries, relationships and information patterns of the studied suppliers

All suppliers express that they experience construction customers as less good at sharing information or sharing information of low quality, hence confirming the coordination challenges seen in earlier studies e.g. Thunberg and Fredriksson (2018). As supplier A puts it *"We have to teach them how to share information"*.. All suppliers except supplier B express a need of more, and right, information about the project before it commences. Why B do not need more information is because they inspect the work as it is carried out and it is of interest for contractor, subcontractors and developer to get the construction inspected and approved. Supplier D seem, on the other hand, to get ALL information and it is up to them to sort out the relevant parts. Suppliers C, E and F would like to take part of the project time plan before the project commence as their deliveries varies with the production phases and have the information on an aggregated level. However, the project time plans of today are too detailed to make sense. Suppliers A, C and E who have the

contractor as the customer have solved the lack of information from contractors through start-up meetings discussing the delivery conditions at site and what services/products the contractor need. Suppliers A, B and C also uses check-lists to make sure they get necessary information, A says *"It is better to ask to much in the beginning than having problems later"*. This is in line with Dubois and Gadde (2000) that state that each project is unique, and this information have to be given each time. However, what is interesting, is that information sharing is not working as expected by Akintoye (1995) and Proverbs and Holt (2000) where the contractor is responsible for information sharing and coordination. Instead, here it is the supplier taking the responsibility, as they are the ones that recognise the problem. At the same time, suppliers D and F, who have the developers or the subcontractors as their customers would like to be involved in the design phase to improve their service and products delivered. Thus, one problem experienced by D and F is that there are products developed by the customer that is not producible for them that with small changes could be produced much cheaper and thereby they could supply a better and cheaper product. Though, for these suppliers it is harder to know who to contact, because of the fragmented CSC and it is not always known who owns the problem (Dubois and Gadde, 2000).

Suppliers also like to have reliable updates of the information during the project. A clear difference can be seen here between the suppliers, depending on if they have continuous supply or few deliveries. The suppliers who are delivering continuously are locally based and present at site on a regular basis and can thereby follow the progress of the construction work. Thus, they know of delays and changes first hand. The suppliers who are not present and delivers a product (D and F) both express a need to have updated project time plans, which they do not get today because lack of internal communication at the contractors between the purchaser, setting the delivery date, and the site manager that knows when the delivery is actually needed. This leads to problems when delivering and to plan their production to avoid unnecessary costs and inventories. As said, these suppliers do not have the contractors as their customers, showing that Azambuja and O´Brien (2009) being right about the contractors are the ones coordinating the CSC, however they seem to think that the responsibility to plan lies within each sub-supplier. Though what the contractors miss are that the overview is in their hands (Thunberg and Fredriksson, 2018). Thus, the contractors do not always priorities their coordination responsibility or understand the supplier's needs of information and thus lack in sharing information with these suppliers that cannot update themselves.

All three suppliers present at site like to increase the services they deliver to the contractors as Proverbs and Holst (2000) suggest, i.e. VMI service from A, planning help from C and cleaning and waste management on site by E. It is not only the potential of selling more that makes these suppliers want to develop these further services, it is also that these further services enable them to improve their existing products and services and also to become a more central supplier to the contractors with whom they have longer contracts with, i.e. going more into partnerships. The more they are on site, the better the two-way information sharing (Proverbs and Holst, 2000) works, it seems.

Based on above discussion we cannot in this study see that there is a difference between supplying services and supplying products in terms of information needed. The difference lies in if the supplier has continuous supply or few deliveries. Based on Mohr and Nevins (1990) information sharing facets (modality, frequency, direction and content) and Jonsson and Myrelid (2016) discussion of information quality, we suggest

	Modality, frequency and direction	Content and quality

Continuous supply	Start-up meetings on-site before production start Continuous check-up either via phone or on-site	Production phases of the project Site conditions Information about services needed and inventory knowledge of tools and materials.
Few deliveries	Interaction during design phase Updates on weekly basis during production	Updated project time plans and installation time plans Changes to product Information relevant to the installation and development of product.

Figure 3, presenting a model for information sharing practices in construction.

	Modality, frequency and direction	Content and quality
Continuous supply	Start-up meetings on-site before production start Continuous check-up either via phone or on-site	Production phases of the project Site conditions Information about services needed and inventory knowledge of tools and materials.
Few deliveries	Interaction during design phase Updates on weekly basis during production	Updated project time plans and installation time plans Changes to product Information relevant to the installation and development of product.

Figure 3 – Suggested information sharing practices in construction

Conclusions

This paper has explored an under researched area: information sharing in CSCs from perspective of the suppliers, thereby making a theoretical contribution to the operations management in construction. Based on this study, we can see that there is a difference between suppliers that are continuously present at site versus suppliers that have very few deliveries. Because of this, the suppliers have different need of information sharing practices (Figure 3). The developed model in

	Modality, frequency and direction	Content and quality
Continuous supply	Start-up meetings on-site before production start Continuous check-up either via phone or on-site	Production phases of the project Site conditions Information about services needed and inventory knowledge of tools and materials.
Few deliveries	Interaction during design phase Updates on weekly basis during production	Updated project time plans and installation time plans Changes to product Information relevant to the installation and development of product.

Figure 3 is to help both contractors and suppliers to understand what type of information different types of suppliers need, how it can be exchanged, and when. This is a

contribution as it makes the information sharing tangible for both parties. The model can be used early in the project to setup an information sharing schedule and thereby improve the efficiency of the suppliers as well as decrease the disturbances of the contractors. Though, this model need further testing before finalized and further studies are suggested outside the Swedish context.

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References

Adriaanse, A. M., Voordijk, H. and Dewulf, G. P. (2004), "Alignment between ICT and communication in construction projects", *International journal of human resources development and management,* Vol. 4, No. 4, pp. 346-357.

Akintoye, A. (1995), "Just-in-time application and implementation for building material management", *Construction Management and Economics,* Vol. 13, No. 2, pp. 105-113.

Aloini, D., Dulmin, R., Mininno, V. and Ponticelli, S. (2012), "Supply chain management: a review of implementation risks in the construction industry", *Business Process Management Journal,* Vol. 18, No. 5, pp. 735-761.

Atkinson, R. (1999), "Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria", *International Journal of Project Management,* Vol. 17, No. 6, pp. 337-342.

Azambuja, M. and O´Brien, W. J. (2009), "Construction Supply Chain Modeling: Issues and Perspectives", in O'Brien, W. J., Formoso, C. T., Vrijhoef, R., & London, K. (Eds.), *Construction Supply Chain Management Handbook* (1 ed.), Taylor & Francis Group.

Bastl, M., Grubic, T., Templar, S., Harrison, A. and Fan, I.-S. (2010), "Inter-organisational costing approaches: the inhibiting factors", *The International Journal of Logistics Management,* Vol. 21, No. 1, pp. 65-88.

Bygballe, L. E. and Ingemansson, M. (2014), "The logic of innovation in construction", *Industrial Marketing Management,* Vol. 43, No. 3, pp. 512-524.

Christopher, M. (2011), *Logistics & Supply Chain Management* (4th ed.), Pearson Education Limited, Dorchester, United Kingdom.

Dubois, A. and Gadde, L.-E. (2000), "Supply strategy and network effects - Purchasing behaviour in the construction industry", *European Journal of Purchasing and Supply Management,* Vol. 6, No. 3-4, pp. 207-215.

Dubois, A. and Gadde, L.-E. (2002), "The construction industry as a loosely coupled system: implications for productivity and innovation", *Construction Management & Economics,* Vol. 20, No. 7, pp. 621-631.

Fawcett, S. E., Osterhaus, P., Magnan, G. M., Brau, J. C. and McCarter, M. W. (2007), "Information sharing and supply chain performance: the role of connectivity and willingness", *Supply Chain Management: An International Journal,* Vol. 12, No. 5, pp. 358-368.

Fellows, R. (2009), "Culture in Supply Chains", in Pryke, S. (Ed.), *Construction Supply Chain Management*, Wiley-Blackwell, Hong Kong, pp. 42-72.

Johansen, E. and Wilson, B. (2006), "Investigating first planning in construction", *Construction Management & Economics,* Vol. 24, No. 12, pp. 1305-1314.

Jonsson, P. and Myrelid, P. (2016), "Supply chain information utilisation: conceptualisation and antecedents", *International Journal of Operations & Production Management,* Vol. 36, No. 12, pp. 1769-1799.

Kaipia, R. and Hartiala, H. (2006), "Information-sharing in supply chains: five proposals on how to proceed", *The International Journal of Logistics Management,* Vol. 17, No. 3, pp. 377-393.

Lacoste, S. and Johnsen, R. E. (2015), "Supplier–customer relationships: A case study of power dynamics", *Journal of Purchasing and Supply Management,* Vol. 21, No. 4, pp. 229-240.

London, K. A. and Kenley, R. (2001), "An industrial organization economic supply chain approach for the construction industry: a review", *Construction Management & Economics,* Vol. 19, No. 8, pp. 777-788.

McKinsey. (2017). *Reinventing Construction: A route to higher productivity*. Report from McKinsey Global Institute

Mohr, J. and Nevin, J. R. (1990), "Communication strategies in marketing channels: A theoretical perspective", *The Journal of Marketing*, No., pp. 36-51.
Murphy, R. (2013), "Strategic planning in construction professional service firms - a study of Irish QS practices", *Constructiom Management & Economics*, Vol. 31, No. 2, pp. 151-166.
Proverbs, D. G. and Holt, G. D. (2000), "Reducing construction costs: European best practice supply chain implications", *European Journal of Purchasing & Supply Management*, Vol. 6, No. 3, pp. 149-158.
Scholman, H. S. A. (1997). *Uitbesteding door Hoofdaannemers*. Report from Economissch Instituut voor de Bouwnijverheid
Seppänen, O. and Peltokorpi, A. (2016). *A New Model for Construction Material Logistics: From Local Optimization of Logistics Towards Global Optimization of On-Site Production System.* Paper presented at the 24th Annual Conference of the International Group for Lean Construction.
Slack, N., Chambers, S. and Johnston, R. (2001), *Operations Management*, Pearson Education, Harlow.
Thunberg, M. and Fredriksson, A. (2018), "[forthcoming] Bringing planning back into the picture – How can supply chain planning aid in dealing with supply chain-related problems in construction?", *Construction Management and Economics*, No., pp. 1-18.
Thunberg, M. and Persson, F. (2014), "Using the SCOR model's performance measurements to improve construction logistics", *Production Planning and Control*, Vol. 25, No. 13-14, pp. 1065-1078.
Tserng, H. P., Yin, S. Y. and Li, S. (2006), "Developing a resource supply chain planning system for construction projects", *Journal of Construction Engineering and Management*, Vol. 132, No. 4, pp. 393-407.
Wacker, J. G. (1998), "A definition of theory: research guidelines for different theory-building research methods in operations management", *Journal of Operations Management*, Vol. 16, No. 4, pp. 361-385.
Weaver, W. (1949), *The mathematics of communication* (Vol. 181).
Wiengarten, F., Humphreys, P., Cao, G., Fynes, B. and McKittrick, A. (2010), "Collaborative supply chain practices and performance: exploring the key role of information quality", *Supply Chain Management: An International Journal*, Vol. 15, No. 6, pp. 463-473.
Williamson, K. (Ed.) (2002). *Research methods for students, academics and professionals: Information management and systems* (2nd ed. Vol. 20). Wagga Wagga, NSW, Australia: Centre for Information Studies, Charles Sturt University.
Vrijhoef, R. and Koskela, L. (2000), "The four roles of supply chain management in construction", *European Journal of Purchasing & Supply Management*, Vol. 6, No. 3-4, pp. 169-178.
Zwikael, O. (2009), "Critical planning processes in construction projects", *Construction Innovation: Information, Process, Management*, Vol. 9, No. 4, pp. 372-387.