

ADVANTAGES OF DECENTRALIZED CONSTRUCTION LOGISTICS

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DOI: <https://doi.org/10.31410/ERAZ.2020.165>

Abstract: *It has to be admitted that the idea decentralized construction logistics, respectively construction site logistics is strongly contested in the scientific literature at the moment. This paper deals with the advantages of decentralized construction logistics. The prevailing view in research is that centralized construction logistics is preferable to decentralized ones. Based on a systematic review of the literature, it is shown that decentralized construction logistics can be advantageous due to the specialization of the construction, different degrees of professionalization, difficulties in cooperation, avoidance of costs and technological inconsistencies and properties as well as with regard to the objects of the construction process.*

Keywords: *Manufacturing, Supply chain, Procurement, Service provider.*

1. INTRODUCTION

It has to be admitted that the idea decentralized construction logistics, respectively construction site logistics is strongly contested in scientific literature at the moment. For example, in a quite recent paper, Le, P. L., et al. (2018) write, referring to the subject of construction supply chain, abbreviated CSC: „An integrated CSC network can solve the existing problems in the construction industry that is known as a decentralized SC“ (p. 1). Decentralized supply chain is identified as a problem. Hofstadler and Mostafa (2010) have been even more blunt: „For large construction projects, when the logistics processes are centrally planned, controlled and monitored, faults can be prevented rather than with individual trades through the decentralized logistics“ (p. 310). Thus, centralized logistics in the domain of construction are believed to be much more reliable than decentralized logistics.

The question how construction logistics should be organized has become almost inevitable for the construction industry. The reason for this lies in the cost-sensitive competition of the construction industry. Expensive deliveries are not timely incoming deliveries, no timely unloading, ineffective warehouse management, use of wrong or damaged parts, missing waste separation on the construction site.

But in view of the diversity of the tasks given, the question arises as to whether the client or with the economic feasibility of involved stakeholders of a construction project should centralize construction logistics, i.e. commission an overall service provider, or whether it would be better, at least for the individual areas - supply or procurement logistics, construction site logistics, waste disposal logistics - resort to appropriate specialists.

Even in this brief overview, the topic seems extremely complex. In this publication, therefore, only a sub-area is dealt with, namely the strengths of decentralized construction logistics. Despite the

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strong tendency towards centralized construction logistics there might be some reasons to promote decentralized construction logistics. Because by inductive reasoning, in at least five cases decentralized construction logistics might be useful: If there is a lack of framework to integrate the different contributions of logistics; if advanced technology has not been fully implemented; if technology for construction logistics seems to support decentralized tendencies; if there is a strong competition among contributors which does not allow central planning; and if synergy effects should be realized. The discussion in the presented paper will verify these and other arguments.

2. RESEARCH METHOD

The research method applied in the paper is the systematic literature review. The aim is to find scientific literature that can help clarify whether and to what extent decentralization in construction logistics bears advantages. To carry out a literature analysis as systematically as possible, it seems helpful to subject it to a kind of configuration process. It is necessary to clarify which elements in which connections should be used therein. Webster and Watson (2002) provide clues such as levels of analysis, temporal and contextual limitations, the range, and the implicit values that the review is subject to.

Almost an examination grid, however, offers Cooper (1988), his taxonomy clarifies which focus, which goals and perspectives, which coverage, which organization and which target group are targeted. Focus is on what kind of material the literature review should scrutinize. In fact, looked for are all the information about advantages of decentralized construction logistics.

As sources for the literature research are chosen: Google Scholar: an easily accessible database that unfortunately does not provide a search mask for elements such as abstract, full text, etc.; Science Direct: freely accessible English-language database with search options for authors, contents, keywords etc. of peer-reviewed journals, articles, books and book chapters on the most diverse fields of knowledge.

3. CONSTRUCTION LOGISTICS

1.1. Concept of construction logistics

According to Schach and Schubert (2010), construction logistics can be understood as follows: „Construction logistics deals with the planning, execution and control of material, personnel and information flows from the point of view of optimized construction-related service provision with regard to deadlines, costs and qualities, while at the same time taking into account safety and health protection as well as ecological aspects“ (p. 7).

For Giesa (2010) the construction logistics service provider is involved in the realization of various services: “These include supply logistics (in particular delivery management and access control), construction site logistics (in particular warehouse management and the organization of crane and elevator capacities) and the disposal logistics (here the collection and disposal of construction site waste). In addition, the construction logistics service providers can also make offers for the rental of equipment that belongs to the site equipment.” (p. 62].

Kirsch (2008), on the other hand, regards construction site logistics as „the design of object flows (goods, information, values) along the supply chain process stages.” He takes a closer look at the

subsections of procurement logistics and production logistics. The former deals with the part „suppliers to the incoming warehouse / construction site”, the latter refers to the „material and goods flows with their accompanying information in their own value creation stages” (p. 68). He points out to the fact that “the flow of materials and information in both subsections can be well distinguished, but on the other hand, the flow of information is always closely linked to the material flow” (p. 68). Thus, various aspects are touched, which concern the field of construction logistics.

1.2. Distinction between centralized and decentralized construction logistics

In the context of the present paper, decentralization in economics and technology has to be pointed out because of the relevance of the subject. (Serugendo, et al., 2004) suggests that “in the field of economics, decentralization does mean usually the distribution of subtasks in different places” (p. 22). He continues (2004) that “in the realm of technology, decentralization can help to manage small, repetitive units that can combine several systems (for example shading, heating and ventilation of a room), the supply to the low-voltage grid to supplement and replace central structures, multiple meshed computing units, in automation technology, the decentralized periphery” (p. 24).

The state of research shows that the difference between centralized and decentralized in construction logistics has not been sufficiently explored. However, the general definitions can be applied to construction logistics. The centralized logistics is characterized by integrating the task of logistics in a single functional area. Pfohl (2018) argues that there are two ways to realize this: “First, one can build up an independent logistic functional area in addition to the other functions or to establish a cross-sectional function overlaying the basic business functions. Second, the logistics tasks can be taken to an existing functional area” (p. 267).

The understanding of decentralized logistics is directly connected to perceived advantages. According to Pfohl (2018), “they might be extremely suitable for large companies with rather independent business divisions which have to take into consideration crucial characteristics of their products as well as requirements of the market. So, it might be of benefit to deploy logistic units over different divisions” (p. 271).

To apply these definitions to construction logistics, it seems suitable to replace the underlying concept of enterprise by the term project. Thus, in the frame of a construction project, centralized logistics can be assigned to an independent functional area, while decentralized logistics can belong to different parts of the process of the project or to different contributors.

3. PARAMETERS OF ADVANTAGES IN CONSTRUCTION SITE LOGISTICS

The current state of research gives information on parameters or factors which seem to decide over the benefit of logistic strategies. In the following, the parameters of framework, area, objects, and phases will be introduced.

3.1. Parameter of framework

The parameter of framework has to be subdivided into different subparameters. They are focused on particularities of the branch, the field of economics, the technology involved, and working in the construction site.

3.1.1. Branch

According to Günthner, et al. (2006) and Hofstadler (2014), construction logistics is characterized by certain properties determined by the branch. “First, one has to take notice of the fact that every construction project including its planning and its execution has to be regarded as unique. Second, the different actions in the construction process have to be periodized in regard to material flow planning, on the one hand, and development of material consolidation on the other hand. Third, limited storage capacity is the rule, therefore, building according to just in time is necessary. Fourth, route optimization is limited because of the domination of single destination trips. Fifth, transport planning depends on the goods to be transported. Sixth, vehicles on the construction site are only individually disposable. Seventh, planning and building depends on weather conditions. Eighth, transportation of custom-made products can only be optimized to a limited extent. Ninth, consortium-orientated coordination needs require compatible logistics systems of the actors. Tenth, the logistics have to be adapted to the condition of disruption-related (repair, malfunctioning, etc.) and personal interruptions of work (breaks, exposure, etc.)” (p. 11 and 82).

3.1.2. Management

Berner, et al. (2013) distinguishes between construction business management and construction logistics. The former deals with the „calculation and billing of construction prices”, the „contract issues in construction”, the „tendering, awarding and billing” of orders, abbreviated AVA, the „contract and contract forms” and the „expiry mechanisms of the construction market”. In contrast, construction logistics, together with project management, occupational science, controlling, risk management and quality management, belong to the field of only construction management (p. 53).

3.1.3. Technology

In construction logistics, technological shifts are mainly triggered by digitization. But there is a wide range of differences according to the state of digitization among enterprises of the branch. Before this background, it seems to be reasonable to differentiate various degrees of digitization with impact on strategies and practices of construction logistics. According to a survey from Germany, only a minority of enterprises has fully digitally developed construction logistics. Most companies have only grade 1, which corresponds more to a persistence on analog media. And the second degree can only be equated with the digital possibilities of the Internet 1.0, insofar as the corresponding applications can only be used to exchange information and knowledge. Simbeck and Bühler (2018) assert that “the level of Web 2.0 with intensive reciprocal interaction is only reached with the third degree, which includes online (project) platforms for planning, preparation, execution, and control and documentation for cloud storage” (pp. 181-199).

Grade 4 represents the level of Industry 4.0 in construction logistics, which is not yet very widely represented in the industry. Industry 4.0 circumscribes the networking between physical and virtual entities. A whole family of technical devices play a key role in the conception of Industry 4.0. To name are BIM design tools, that is Building Information Modeling in 3D, Global Positioning System (GPS) for precise unloading of transports on construction sites, the Radio Frequency Identification technology (RFID), which allows contactless identification, assignment and traceability of construction and building materials and the documentation. The systems

for visual pattern recognition refer to cyber-physical systems (CPS) that is the self-control and self-organization of real and virtual elements, which at least partially operate independently and thereby can gain the status of production units, abbreviated CPPS. According to Simbeck and Bühler (2018), CPPS consists of „flexible, autonomous and self-configuring production resources that can communicate with each other and with products (so-called smart products, that is products with CPS architecture) and make situation-specific decisions.” (p. 190).

3.1.4. Compliance with the construction logistics manual

The construction logistics manual provides the contractual basis for all rights and obligations for all actors involved in the construction project. These stakeholders include not only builders and planners, but also the contractors and all active downstream companies plus suppliers and other service providers. They have to deal with a set of rules whose non-compliance is sanctioned. Based on the construction logistics handbook, written by Ruhl, et al. (2018), the construction logistics concept is realized and cooperation in the building logistics processes is placed on a systematic basis. In the course of this, the individual construction logistics processes and their implementation are precisely defined and assigned to the responsible persons.

3.2. Parameter of domain

Based on the handbook by Girmscheid (2016), construction logistics is generally subdivided into three areas of supply logistics (includes logistics right to the construction site), construction site and production logistics (deals with logistics on the construction site), and waste disposal logistics (the logistics after the construction site), which are subordinate in terms of time.

3.3. Parameter of objects

Central construction logistics can also become relevant for the efficient handling of objects in construction logistics, where the resources required for the services to be created are named as objects, regardless of whether an object is a house or an infrastructure or something else. Furthermore, according to Schach and Schubert (2010), there is a difference between object planning and object realization. There are “supply logistics objects, site logistics objects, which relate to all transfer movements relating to transport, handling and storage, and objects of the waste disposal logistics concerning the recovery and disposal of construction waste accumulating on a construction site” (p. 7-13).

3.4. Parameter of phases

To construction logistics, the structure of different phases of work also matters. Especially the phase of expansion is of importance. This applies to the organization of the trades as well as to the transportation tasks which are indispensable during all phases. Each construction phase goes through a planning phase and a realization phase. Ruhl, et al. (2018) have listed four phases that the construction logistics have to go through and which Ruhl assigns to his multi-stage process model under the planner heading to the overall process: construction logistics initiation (Phase 1), construction logistics planning (Phase 2), construction logistics organization (Phase 3), construction logistics realization (Phase 4).

4. POSSIBLE ADVANTAGES OF DECENTRALIZED CONSTRUCTION SITE LOGISTICS

4.1. Discussing the parameter of framework

The state of affairs in the branch of construction itself seems to require decentralized logistics. One reason is that customer demands are often very specific. To fulfill the needs of the customer, there is little chance that a single company may be sufficient. Instead, specialists from other companies have to be brought in. But in this case, as Gollos (2014) argues, “it is hardly imaginable that these actors might work under a general logistics umbrella” (p. 45). Due to the fact that the different tasks of construction can hardly be compared, it appears doubtful if not only cross-company but also cross-task logistics can be realizable.

Second, the situation of competition among companies as well as low capacities and cost-pressure have led to off-shoring or the use of subcontractors. Thus, different conditions of work, different corporate cultures and different kinds and levels of professional qualifications are at work on a construction site. Because of the differences among the people involved it seems to be improbable that they can be adapted to common rules and a required set of technical devices. At least, it might cost much time, effort and money to create such a situation. Therefore, decentralized logistics seem to be much more realistic.

Third, there is little evidence for willingness to work together among companies. On the contrary, studies have brought to light that members of construction companies are filled with psychological distrust of other companies and fears of loss of identity and self-reliance. So, it appears advisable, according to Brandt, (et al.) (2016), “to let the different companies have their own set of logistics to avoid conflicts and distrust” (p. 18).

But there are also economic reasons which shed light on the advantages of decentralized logistics as well. From the construction business management point of view, central construction logistics are higher compared to decentralized construction logistics.

As far as technology is concerned, different problems arise to which point to decentralize logistics as a good solution. First of all, it has to be taken into consideration that the construction companies on the market operate at different technology levels. In the context of centralized logistics, it would be difficult to oblige all companies involved in a project to make their logistics work at a certain technological level. Theoretically, it would be conceivable, for example, to make a medium level - about level 2 - or a high level - level 4 of the digitalization of logistics binding. However, this would most likely disrupt the well-established work processes or their organization. In any case, whether the level of digitization is below or above the usual standard, companies would be hampered in their performance and others would be overwhelmed. In order to guarantee the individual performance of the companies, decentralized logistics seems suitable because it is tailored to the requirements and potential of the individual companies.

Furthermore, it is not absolutely clear if advanced technology would be successfully applied by the involved agents. For example, log-on systems for transportation purposes might not work efficiently because of reluctance to use them. Another disadvantage arises if the deliveries not registered via the online system, but delayed, or even not registered, are rejected.

In addition, the highest level of digitization that is accessible to logistics, namely at the level of the Internet of Things, raises the question of whether central logistics is still possible or just decentralized. It should be borne in mind that the objects in the sense of the CPS are at least partially autonomous and have artificial intelligence. This enables them to make decisions independently, based on communication with other objects. Under these conditions, doubts arise as to whether logistics can be thought and organized hierarchically for a long time.

4.2. Discussing the parameter of objects

Regarding the objects used in the building process, it has already been determined that decentralized logistics is recommended for them because they can act independently. They can make local decisions based on their artificial intelligence and can communicate with other objects as well as people. It should now be added that these so-called smart objects are able to adapt flexibly to their environment and the tasks they perform due to their described skills. They can also be considered autonomous in this regard. However, in this respect Anderseck, et al. (2013) suggests that “the building logistics should not be organized from a central point, but from the objects that are involved in the building process” (p. 54).

A completely different kind of objects are models and simulations for the building process. They are not installed, but they manage the installation process and have a major impact on logistics. The concept of the digital construction site according to Günthner, et al. (2006) stipulates that “a BIM model is the central requirement for all logistical activities” (p. 77). In reality, however, this is often not the case. According to Greiner and Scherer (2014), “the conflict is rather that, on the one hand, data is to be collected and made accessible by means of a central building model, but, on the other hand, there is an increasing tendency among contractors to build their own models for their own cost calculations and work preparations, because there are always doubts concerning the actuality and completeness of the other models. It is therefore an adjustment to existing conditions to accept not only the existence of one’s own construction models, but also independent logistics that are based on this model and that therefore can only be realized in a decentralized form (p. 151-166).

5. FUTURE RESEARCH DIRECTIONS

As the paper suggests, decentralized construction logistics has its own advantages. However, the same can be said about centralized construction logistics. As this paper focuses on the advantages of decentralized construction logistics, it is advisable to analyze also the advantages of centralized construction logistics and to compare these two types of logistics.

6. CONCLUSION

The conclusions are drawn that refer to the general framework in the subject-specific scientific literature. These consist in the fact that the highly specialized manufacturing entails independent logistics systems, that different degrees of professionalization and corporate cultures do not allow any other than decentralized logistics, as well as the widespread unwillingness to work together. In addition, decentralized logistics is considered less expensive than centralized. Finally, decentralized logistics does justice to the different technology levels of the company. But even if digitization shows the last point of development in the company, decentralized logistics seem to be more accommodating due to the decentralization of the Internet of Things. In addi-

tion to the general framework, you can also state that objects handled on the construction site, whether they are intelligent, decisive smart objects or models or simulations, seem to be more useful with decentralized logistics. There are no advantages for decentralized logistics in other areas such as domain and phases discovered in the literature.

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