

Co-ordinating the supply chain - Diffusing Lean Production in Construction

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1. General introduction

This paper discusses the importance of co-ordinating the supply chain in the building process in the Netherlands in the case of implementing the lean production philosophy.

When the primary goal of lean production, avoiding waste, is obeyed, the lean production philosophy exploits simultaneously the advantages of craftwork and mass-production in terms of flexibility, quality, cost and time per piece, which results in a significant increase in added value in the total production chain. Principles of craftwork and mass-production are to be recognised within the framework of the construction industry in the Netherlands as well.

However, the advantages of both production philosophies are not exploited optimally within the construction industry in the Netherlands. Research showed that the quality lags far behind what might be expected of a craftwork industry, while at the same time a changing market makes greater demands on the already flexible general contractors. More and more, both the positive and negative aspects of mass-production in construction can be seen. The shift from added value towards the preliminary stage of the production chain indicates that there is relatively more industrial production and that sub-contractors increasingly specialise.

Because of the increasing number of parties involved, general contractors obtain more and more the role of a co-ordinator who has to be able to react flexibly to all the demands made with regard to quality, cost and time. However, the lack of stable forms of co-operation within the building process leaves general contractors without the structure and the instruments needed to perform optimally. This could be related to the price-oriented culture per project within the production chain.

An integral approach of lean production techniques will exact the exploitation of the advantages of craft industry and mass-production. Co-ordinating the supply chain, based on the lean production philosophy, provides the co-ordinating contractor with a sound point of departure to diffuse lean production in the construction industry in the Netherlands.

2. The origin of lean production and its basic principles

Like the principle of the assembly line, which was introduced by HENRY FORD in 1913 and was copied throughout the world by many companies, the production method used by several Japanese companies has become an example for American and European companies in the car industry. This innovative Japanese production method is being developed since the Fifties. Especially Toyota's implementation is very famous. It is this production system that is also called the Toyota or Lean Production System.

Although Japanese companies gained market share, because of their Lean Production System, the Western companies did not seem to be able to learn from their Japanese competitors. Even

though various individual factors in the Japanese system have been known for some time, this is still the case with some companies globally. This doesn't mean all the Japanese companies are lean and use lean production methods or all Western companies rejected those lean production methods. For the most part this shortcoming is undoubtedly due to a critical misjudgement. Western managers have wanted to integrate such individual factors as Quality Circle and Just-in-Time production into their own already existing organizational structures without grasping the overall strategic approach [4].

A five-year in-depth study of the practices of ninety auto assembly plants in several countries executed by researchers of Massachusetts Institute of Technology and their interviews with individual employees, scholars, and union and government officials uncovers the specific manufacturing techniques behind Japan's success and show how Western industry can implement these innovative methods. The results of this research are collected by WOMACK, JONES and ROOS, in the book "*The machine that changed the world*", published in 1990 [2].

As already mentioned, lean production does not include actually new principles of management techniques. It merely combines existing principles in a new way. The primary goal of lean production is to avoid waste (Japanese: "muda") [1]. Lean production exploits the advantages of craftwork (quality and flexibility) and mass-production (cost and time per piece) which results in an increase of added value (see Fig. 1).

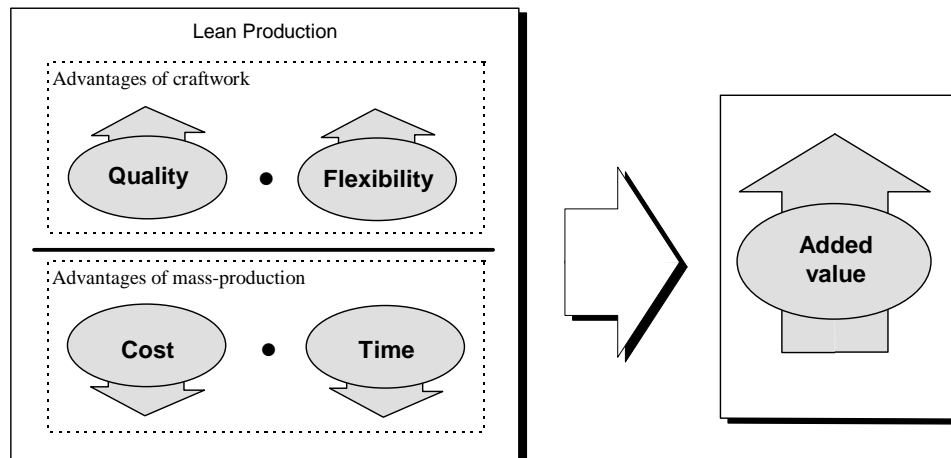


Fig. 1

In order to create a lean production company a number of usually familiar techniques are implemented which techniques are strongly correlated by the principles of lean production. The most important techniques are:

- multifunctional task groups
- simultaneous engineering
- Kaizen
- Just-in-Time deliveries
- Co-makership
- customer orientation
- information, communication and process structure

The above-mentioned techniques are already being implemented on a large scale in the production industry and some elements are being used in the construction industry already [1]. However, there are a number of differences between the two environments which have to be taken into account [5]. This topic has been discussed in detail in many articles published within the framework of the 'Production Control in Construction'-research project [5]. A collective review of published literature was also carried out in collaboration with a research group at Stanford University [9]. For example, construction involves the manufacture of unique end-products in separate locations, whereas manufacturing involves the use of static production resources for similar products; construction has a minimum level of automation compared with manufacturing industry. In addition, the implementation of Lean Production will require a radical cultural change from the established construction methods and many of the elements of Lean Production can not be directly transferred to construction.

3. The added value in the construction industry in the Netherlands and the influence of lean production

3.1. Introduction

Hidden behind the organisational forms of the building process one finds the reality of who manages to seize the largest share of added value in the building process?

As mentioned before, an important increase in added value can be obtained by implementing a concept which on the one hand divides the products in easily interchangeable parts that can be produced in large amounts (mass-production) and on the other hand ensures that the products offered comply fully with the demands and wishes of a specific buyer, so that every final product is one of a kind (craft industry).

The construction industry in the Netherlands is changing as well and it is important to respond to the increasing relevance of quality and flexibility; at the same time further cost reductions and production cycle time reductions have to be sought through industrialisation of the building process. Research into the implementation of the lean production philosophy as an overall strategic approach of this process of change within the construction industry in the Netherlands (as is being carried out by the Delft University of Technology), can be justified because of the characteristics of this philosophy.

An outlined description of the way in which the construction industry in the Netherlands gives its interpretation to the above-mentioned process of change is the basis for an argument about the importance of lean production in construction in general, and the importance of coordinating the supply chain in particular.

3.2. The increasing importance of quality and flexibility in construction

The construction industry is a specific branch, of old working according to traditional methods. However, it can be stated that the quality in the construction industry falls short of the expectations one may have of a craftwork industry. The failure costs in the construction industry are considerable. KOSKELA gave an overview of waste in construction. He found results amounting to 6 to 10% of the total project costs in Sweden and the USA [1]. Research into construction companies in the Netherlands gave the same results. Quick scans gave a result of failure costs (costs to restore failures) amounting to at least 6% of the project costs [1]. To drive back these failure costs many constructors think it important to implement a

quality care system. On the part of the principals there is an increasing demand for companies to work with demonstrably well functioning quality systems. It is expected that in the future government bodies will only co-operate with certified companies. In view of the principals' line of policy it is essential for constructors to strive to obtain an ISO-certificate. In this case commercial considerations, i.e. demands on the market, are more important than the actual functions of ISO. According to BERGER en VAN DEN BOOGAART [12], expected more efficient and uniform working methods, better transferability and the demonstrability of a controlled process are of minor importance.

In view of the unique character of each end product it can already be stated that the construction industry is flexible with regard to the principals' specific wishes. Since the construction industry is always changing, the question arises to what extent the flexibility of the construction industry complies with the present demands on the market. In order to answer that question, a description will be given of the way in which the construction companies in the Netherlands anticipate changing demands on the market with respect to flexibility. A distinction will be made between flexibility with regard to the specific wishes of a principal and flexibility of the construction industry with regard to a changing capability demand.

The construction industry is cyclically sensitive and much influenced by changes in rates of interest and changeable consumer trust [10]. In the process of building and using, numerous supply and demand relations play a part on markets that are - to a greater or lesser extent - regulated by the government. These markets are closely connected. An executive building company can act as a constructor but also as a project developer or a designer. In practice a very large number of companies all act in various capacities.

In the last two decades, however, the construction market in the Netherlands seems to be changing pointedly in character. As a result of cuts in government spending and because of the European unification the government is increasingly withdrawing from the market [10]. In [10] PRIES indicates that government influence decreased from over 40% to less than 30%, thus changing the construction market from a "regulated market" into a "free market". This results in a more direct relation between construction companies and end users. VOORDIJK [7] observes a gradual withdrawal of the government as a regulative and controlling force on the market. According to VOORDIJK [7] more market and less government results in a greater consumer influence on the end product. A rising demand for diversity in supply, both in price and quality of workmanship, is the result. The construction market develops from a supply market into a demand market. Consumer and user interest are becoming more and more prominent. Since it is required more than ever to solicit the consumer's favour, a different attitude of all construction partners is called for [3]. The buyer wants a solid and attractive product, without flaws, a product that complies with the functional, physical and building physical demands the buyer defined. Moreover, the buyer wants guarantees, delivery on time and does not want to pay too much. All the more reason to tune building process in on the buyer. Tuning in on the more and more exacting demands requires a greater degree of flexibility than has been customary in the mass-production of buildings in the Netherlands.

Apart from this, however, the often unpredictable fluctuations of the building market ask for a flexible organisation with respect to the capacity of the construction industry. Demand can suddenly change under influence of unexpected external factors and of alterations in government policies. A striking example is the reunification of Germany, which nobody could predict timely, and which lead to an enormous increase in demand for new building

production over a short period of time, thus having its effect on building companies. Another example can be found in Finland. In three years time building production fell with about 40%, coinciding with the also collapsing economy, this being a reaction to the political and economic events in the Baltic states and Russia [3]. At this moment the fall in demand on the German construction market causes problems for building companies. The construction market can be characterised as a cyclical branch because of its sensitivity to economic fluctuations [10].

The construction industry involves sub-contractors on a large scale in order to create the degree of flexibility required [8]. One of the most important reasons for bringing in sub-contractors is the increase in work, i.e. tuning in supply on demand. It are largely the smaller companies that involve sub-contractors. As a result, employment in the companies of sub-contractors seems to be affected more by economic fluctuations than employment in the companies of general contractors [11]. Contractors are cautious about hiring employees after a serious collapse in production and prefer involving a sub-contractor when the amount of work increases; a development partly due to lengthy dismissal procedures [8]. Another possibility to approach the market flexibly is - as almost all building companies are doing - not to choose for a particular market segment, but to spread the risk. Companies are “good at everything”, so that if a collapse occurs in a particular market segment, another market segment can compensate for a disappointing turnover [10]. According to PRIES [10] a flexible market approach is also made possible by a number of typical characteristics of the construction industry, such as: low capital intensity, solely price-competition, little specialisation.

3.3. The advantages of mass-production in construction

In the Fifties some companies experimented with fully prefabricated houses in an attempt to reduce building costs and production cycle time. A detailed study was made of productivity on construction sites in order to introduce mass-production into the construction industry in the Netherlands. The highest level of delivery, i.e. prefabrication of an entire building, has regularly been an object of study in recent years. However, projects of this kind regularly failed. In their epilogue WOMACK, JONES and ROOS comment upon mass-production in construction: *“In addition, mass production was tried, without much success, in one-of-a-kind craft industries - in particular housing, where a number of entrepreneurs set out to become the Henry Ford of the home.”* [2].

In the Seventies this one-sided orientation towards productivity disappeared gradually from house-building in the Netherlands. Demand changed as a result of a withdrawing government which used to create a uniform demand by its regulating, financial and commissioning influence. In order to join in with an increasingly varying demand, a shift occurred from large-scale production (which is very suitable for improving efficiency) to more small-scale projects which are still being mass-produced [10].

Even though mass-production is not to be found on the building site itself, a distinctive influence of mass-production on meso-level can be observed. An example hereof is the ongoing fragmentation of the building process which involves an increasing specialisation/division of functions. Through the years the share of payments received by sub-contractors and ancillary industries from general contractors has increased. The ongoing specialisation, as a result of which main constructors perform less traditional work, can be seen as one of the causes for this shift in work. Moreover, the importance of industrial

expenditure has increased. The so-called preliminary stage accounts for an increasing share of the contract price, as a result of which a larger share of the added value shifts towards the preliminary stage at the expense of production on the building site.

Increasingly it is possible to take advantage of the positive characteristics of mass-production. The characteristics experienced as positive are, amongst others, conditioned circumstances, (less) restriction to a particular area, serial-effects so that economies of scale can originate, and the substitution of labour by capital. The activities on a building site can increasingly consist of assembling prefabricated parts. The prefabricated parts can be roughly divided into two categories: project bound and project unbound prefabs.

The shift of added value towards the preliminary stage is not surprising if one takes into account the innovation in construction. In [10] PRIES: *“It turns out that the ancillary industry accounts for the largest share of innovations in the Dutch construction industry: over 70%. Of all product innovations about 80% can be contributed to the ancillary industry. The ancillary industry can be said to monopolise product innovation. The ancillary industry also accounts for almost half of all process innovations.”*

The traditional building process, where a large number of relatively independently operating sub-contractors and specialists cooperate for the duration of a project, causes the main constructor to become more and more a co-ordinator of the total building process. Often the operating companies differ considerably with regard to size, place on the market and culture. However, because of the usually unique and complicated character of a project, for every new project several of these different, relatively independent companies are separately contracted by or on behalf of the principal. This so-called bilateral contracting causes many imperfections and insecurities [6], [7]. In [7] VOORDIJK indicates that tuning sub-contractors optimally in on each other is hindered by the fact that the different parties are selected independent from each other and are not always informed about the agreements made with other parties. This results in “a faulty process which generates a lot of waste by, for example, changes of time schedules, a strong variation in capacity, unnecessary delays, extra repair costs etc. In [7] VOORDIJK argues that the price-oriented culture of the construction industry in the Netherlands causes the absence of stable forms of co-operation to exist during a number of projects.

In order to co-ordinate the building process optimally, a development is going on in the Netherlands whereby specialists instead of general contractors take the task of co-ordinating upon themselves in the capacity of construction advisors/managers. PRIES claims in [10] that about 40% of the building production costs can one way or another be related to communication. Although in recent years a lot of energy has been dedicated to improving the flow of information in the construction industry it can still be argued that successful communication is missing at the moment. This is even more poignant since construction involves co-operation between different parties and, therefore, the flow of information is essential [10].

In view of the shift of activities towards the preliminary stage of the building process and the ongoing specialisation involved, it can be stated that the costs which can in one way or another be related to communication, will increase.

3.4. The meaning of lean production in construction in the Netherlands

In the building process in the Netherlands the increasing relevance of quality and flexibility is noticeable as well and by industrialising the building process building companies strive for reductions in costs and time in order to increase their added value. However, it turns out that a considerable share of the added value moves towards the preliminary stage at the expense of the production on the building site. Both PRIES [10] and BUUR [13] conclude that it is no exception that in building a house, the contribution of contractors' companies leads only to a 20% increase in value.

Controlling relations between sub-contractors and supply companies on the one hand and principals on the other hand has gained a primary interest by the increase in the share of sub-contractors and supply companies in the total building process. The contractor has to function more and more as a co-ordinator, while by or on behalf of the principal ever different sub-contractors and supply companies are bilaterally contracted which leads to many imperfections and insecurities. The lack of stable forms of co-operation within the building process does not provide the general contractor with the structure and instruments required to perform the role of co-ordinator optimally.

In fact the general contractor finds himself caught between two fires. On the one hand the contractor is confronted with a demanding principal and on the other hand the contractor is forced to use new product and process innovations by the ancillary industry.

By reducing the failure costs through the use of Quality Circle and by bringing in a multitude of specialised sub-contractors, presently general contractors attempt to react flexibly to the capacity demanded in order to increase the added value. Even though general contractors try to reduce building costs and time through the use of product and process innovations, these are only incremental and are both monopolised by the ancillary industry. On the other hand, general contractors are organising suppliers and sub-contractors in vertical chains and playing them against each other in search of the lowest short-term costs as a results of which the horizontal flow of information between suppliers - particularly with regard to advances in productions techniques - is blocked. Here the question arises whether the wishes of the principal are converted optimally into product and process innovations.

The lean production philosophy provides the construction industry in the Netherlands with the overall strategic approach that results in a better, more cost-efficient product, higher productivity and simultaneously greater customer loyalty. In view of the innovative power of suppliers in the construction industry and the ongoing specialisation within the building process the co-ordination of the supply chain is regarded to be an important step toward diffusing lean production in the construction industry in the Netherlands.

4. Coordinating the supply chain

After all, the Delft Lean Construction Group regards the co-ordination of the supply chain as a sound point of departure to diffuse the lean production philosophy in the construction industry in the Netherlands. For that, it is being worked on within the Delft Lean Construction Group in order to come to stable forms of co-operation within the building process in the Netherlands. The developments are supported by the construction industry in the Netherlands (e.g. general contractors, ancillary industry, sub-contractors, etc.).

A lean supply chain, which has to provide the general contractor the lasting structure and instruments required in order to perform the role of co-ordinator optimally, is strived after. To attain the before mentioned structure with matching techniques, possibilities to decrease the total amount of flow of goods with the parallel flow of information (lean tiering) will be explored in the first instance. A formation of practically mutual independent clusters/business-units of flow of goods and matching flow of information, which are correlated in a standard way, is a possibility which will be explored in the first instance. The principle of a clustered flow of goods is presented in Fig. 2. Within a clustered flow of goods/business-unit, components are fabricated as part of a building-work in order to reduce the general contractors' span-of-control.

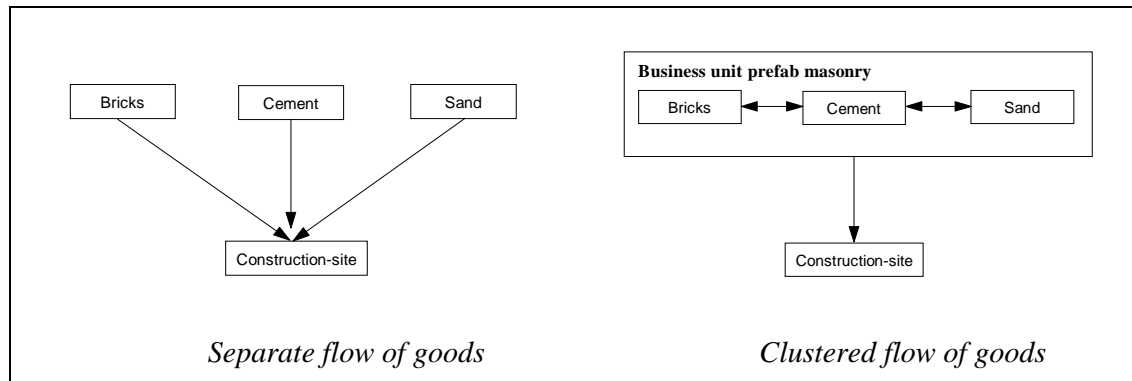


Fig. 2

A formation of business-units (i.c. lean tiering) in the construction industry in the Netherlands requires a co-operation in a horizontal and vertical sense within the production chain, which is blocked until now due to the price oriented culture of the construction industry in the Netherlands. For that purpose, the Delft Lean Construction Group started the execution of an in-depth feasibility study into excessive forms of co-operation in the building process in the Netherlands, taking into account the lean production techniques as concurrent engineering [e.g. 14] and co-makship in particular, in order to create a sound basis for diffusing lean production in the construction industry in the Netherlands.

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