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Responsiveness and Flexibility in a Decentralized Supply Chain

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Abstract

Today's supply chains are not capable of managing the instabilities that is the case in the market. Instead, there is a need to develop supply chains that are capable of adapting to changes. Through a case study of LEGO, the authors suggest a possible solution: a decentralized supply chain serving independent and self-sufficient local factories. The decentralized supply chain is provided with materials, parts and pre-assembled elements from local suppliers and supplies the local market in return.

Keywords: Decentralize, Responsiveness, Flexibility

Introduction

Presently, manufacturers are facing major challenges with their global supply chains. The structure of these was designed 30 years ago in a time of market stability therefore manufacturers are not capable of managing the instabilities in the market today (Christopher & Holweg, 2011). In the past, companies have faced temporary instabilities as a result of temporary market shocks, e.g. oil fluctuations, and each time a return to stability has been seen. However, as it seems today, the instabilities are not only a temporary shock that will pass. Not only are the oil prices higher than ever, many commodities and raw materials are also facing unprecedented levels of volatility. This is the reason it is important that companies start a process of re-designing their supply chains to be able to cope with the volatile market. In other words, a supply chain that is capable of adapting to changes is needed.

In this paper, the authors will try to identify some of the challenges that companies working in a global structure are facing. Hereafter, these general challenges will be tested in a case study of LEGO System A/S (LEGO) to verify that the challenges listed in the literature are true. LEGO was chosen as a case study since it is a global company with a complex supply chain. It will be identified if the challenges can be solved by the concept of decentralizing their supply chain. The result will be used to build on the theory of decentralized supply chains.

The Global Supply Chain

Global sourcing became a reality already in the late '80s (Christopher, Peck, & Towill, 2010; Meixell & Gargeya, 2005). This was due to geopolitical events, the development of technologies and the deregulation of trade (Christopher et al., 2010). Globalization created a new landscape for the manufacturing industry driven by fierce competition, short windows of market opportunity, frequent product introductions and rapid changes in demand (Koren, 2010). Christopher et al. (2010) argues that the old norms of manufacturing and sourcing 'local for local' has been overtaken by the more global perspective that has opened the door to the 'global village'. Cost savings, especially because of lower wages and fewer regulatory controls, has tempted companies to mass-migrate their manufacturing from the developed world to the more emergent economies in other regions. A favored destination for the manufacturing industry has been China, for the same reasons mentioned above (Christopher et al., 2010). The global supply chain has brought new opportunities for companies but has also made it important that all companies belonging to the supply chain cooperates closely (Meixell & Gargeya, 2005). In order to capitalize on the opportunities, the manufacturing industry needed to offer products that were innovative and products that could be made to appeal to buyers in many cultures (Koren, 2010).

In order to achieve the above, the supply chain that surrounds the company needs to be able to provide for these necessities. When designing a supply chain, decisions regarding the number and location of production facilities have to be made. Other factors that need to be included in the design decisions are: the capacity at each facility, which in reality is very dynamic because of continuous changes in demands, the assignment of each market region to one or more locations and supplier selection for sub-assemblies, components and materials (Chopra & Meindl, 2004). In addition, storage facilities and distribution centers need to be thought of when the decisions are made. However, when designing a global supply chain, this definition extends to include selection of facilities at international locations and also the special globalization factor that this involves. These design decisions can be decentralized, such that a manager at each facility makes decisions, or they can be centralized so that decisions for all facilities are coordinated (Meixell & Gargeya, 2005). Meixell & Gargeya (2005) points out that, ideally, managers should make these decisions in consistency with the company's supply chain strategy.

Challenges in the Global Supply Chain

According to Christopher et al. (2010) a paradox is connected to globalization, since the supposedly low-cost offshore sourcing strategies can end up as high-cost supply chain outcomes instead. The reasons are often complex, but there are some seemingly obvious factors that are often overlooked. Some of the most obvious ones are **higher transport costs** due to the greater distances covered but also geopolitics is a factor (Christopher et al., 2010; Levy, 1997). Because of stable oil prices, the East-West trade has benefitted from relatively low transport costs for many years. The uncertainty in the oil market before and after the invasion of Iraq in 2003 led by the US, raised questions about the longer-term viability of global supply chains (New, 2003). Today's increases in the oil prices do not aid the global supply chains (Christopher & Holweg, 2011). Johnson (2001) further argues that because more and more manufacturers are heading for China, the shipping prices have risen sharply and seasonal shortages in freight capacity have then emerged.

Another, less obvious, cost driver is the **extension in lead times** that is a result of the greater distances and the almost inevitable complications involved with the coordination of the shipments from suppliers far away, through forwarders, shippers, customs and delivery networks (Christopher et al., 2010; Levy, 1997). This also **adds to the complexity of the supply chain** because when companies choose to go global, the complexity of their supply chain increases. There are several reasons for this but some of them are the **material flow of raw materials, work-in-progress (WIP), and finished products** between manufacturing facilities that has to be controlled. When mapping material flow in global supply chains, the complexity becomes apparent (Mentzer & Manuj, 2008; Milgate, 2001). Furthermore is it required that the company in question have the ability to **manage across diverse cultural, legal and regulatory environments**.

In general, when Western companies choose to locate their production facilities in China and other low labor cost countries, it results in a need for **larger inventories**. Keeping inventory costs a lot of money not only because a lot of money is tied up in products but also because the operation and management of inventory is expensive. There is also a risk that the products lying in the inventory will become obsolete with time. These extra expenses can easily be higher than the money saved from lower laboring costs. (Christopher et al., 2010)

In many markets, time and service are important competitive variables. This is not just regarding the time-to-market for new product introductions but also regarding the **time-to-respond in terms of being able to meet the needs of time-sensitive customers** (Christopher et al., 2010). An example is in the apparel industry where this is a crucial factor. Here the lead-times have actually increased during the last decade, primarily because of the global sourcing structure. The risk that follows with longer lead-times can be considerable because decisions on style, color and quantity have to be taken months ahead of the season. Because of this, there is a greater **chance of error in the forecast** (Christopher et al., 2010).

Another risk in the global supply chain is **finding the right inventory levels**. Companies that differentiates themselves from competitors through innovative new products must tread the fine line between the danger of over-optimistic forecasts to the danger of wasted opportunities arising from an inability to supply quickly enough when a winning product is produced (Christopher et al., 2010). Not only does greater distances result in increased inventory but it also results in a need for **higher levels of safety stock** (Levy, 1997). With longer and more uncertain lead-times, safety stocks must cope with fluctuating demand and disruptions affecting both production and suppliers. Longer lead-times also increase the volatility of inventories over time and volatile inventory levels are likely to increase administration costs (Levy, 1997). Hence, is it important to find the right inventory level to be able to minimize the risk from failed products and to maximize the benefits of successful innovations before the margins fall as competitors follow up with cheaper, less risky, 'me-too' products (Christopher et al., 2010).

In summary, the challenges that comprise global supply chains are:

- The greater distances and inevitable complications involved with coordinating shipments from suppliers results in extended lead-times
- The complexity of the supply chain is increased when working globally
- It is required from the company that they have the ability to manage across diverse cultural, legal and regulatory environments
- The management of inventory levels. The more global, the more inventory is needed and thus the costs also increase
- The time-to-respond to customer's needs is increased due to the global perspective of the supply chain
- Risk of volatility in inventory levels over time due to greater distances
- Treading the fine line between over-optimistic forecasts and the danger of wasted opportunity
- Materials, WIP and finished products are transported greater distances causing the transportation costs to increase and together with unstable oil prices questions the future for global supply chains
- As more and more manufacturers are manufacturing in China, the shipping prices have risen sharply and seasonal shortages in freight capacity have emerged

LEGO as a case

The global toy manufacturer LEGO was chosen for a case study to verify that the challenges identified in the literature are true. Furthermore, the study was used to build upon the theory of decentralized supply chains. The authors studied LEGO's supply chain and key personnel were interviewed (B. Stensballe, Supply Chain and Planning, March 26, 2012; J. Kelley, Operational Models, March 28, 2012; Manel Romeu Bellés, Operating Model Leverage, May 3, 2012; Thomas Steen Jensen, Portfolio Management, May 7, 2012). LEGO has started an **early stage of decentralizing** the supply chain by wanting to separate their two main markets: Europe/Asia and the US. The US market is served from a rather new production facility located in Monterrey, Mexico, while the European/Asian market is served from production facilities that are spread around in three countries in Europe: Denmark, the Czech Republic and Hungary. The facilities in Europe each handle their own processes and **the result is a high level of material flow** between them. The literature identified that sourcing from China is becoming more and more expensive. LEGO has also identified this and is investigating into the topic.

When an order from a customer is received by LEGO, a process is started where the order is picked at the DC and then shipped to the customer. This means that **the decoupling point is located at the DC**, as this is where the forecast meets with real demand. The production processes consist of molding, assembly and decoration. After these, the products are packed. It takes 90 days to go from raw material to a finished product in the DC. From the DC, the delivery time is 7-14 days. LEGO's supply chain is designed so that there are **several inventories between the processes**, to ensure that customers should not wait over three months to receive a product.

As mentioned above, LEGO has **a lot of material flow** of pre-assemblies and unfinished goods to be processes between their facilities. This being that their production facilities is handling different processes. The spread facilities also **drive inventories to increase** since an inventory is needed between all the processes. The supply chain design with inventories at several stages also increases the inventory levels. The high level of **material flow increases the supply chain's complexity** making it a challenging task to plan and coordinate the production of products.

LEGO's products have a **high seasonality factor**, with a boom in sales in the months before Christmas. In the fast moving toy industry there is a high need to innovate products all the time. This result in various new product launches every year. Together with the seasonality factor, this makes the process of **forecasting very difficult**.

The analysis of the data showed that LEGO was facing the same challenges that were found in the literature. In the following these have been recapped to show which challenges that are to be solved using a possible new supply chain paradigm:

- A desire to decrease lead-times
- LEGO wishes to reduce inventory levels
- The overall complexity is high due to the spread facilities and this causes a lot of material flow
- The company is facing challenges with forecasting. LEGO's products have a high seasonality factor making it even harder to forecast
- Materials, WIP and finished products are transported great distances, causing transportation costs to increase

Decentralizing the supply chain

This section will explain the concept of decentralized supply chains and will present the author's ideas of the concept. The word 'decentralize' means "to distribute the administrative functions or powers of a central authority among several local authorities" and "to reorganize (a government, industry, etc.) into smaller more autonomous units" (The Free Dictionary, 2012). Christopher & Holweg (2011) suggest that companies should consider having a manufacturing facility in each of their markets. Christopher & Holweg (2011) suggest that the decision to spread the production should not be to achieve lower labor costs but instead to be closer to the customer and to markets. They also suggest that supply chains should be arranged accordingly and state that it actually makes sense to have suppliers in each of the main markets. Abele et al. (2002) states that products which have to meet specific customer orders, fulfill a certain market taste or are dependent on a short lead time, need to be manufactured locally and close to its market. They further state that the competitive advantage that is gained by producing locally, cannot be compensated by other means and that these conditions typically favor a polycentric, multinational production setup – what the authors call decentralization. This means that the production of the products will be done locally, close to the customer, in order to overcome the challenges specified above.

The solution presented in this paper is a setup of factories serving decentralized supply chains. The factory is local and independent and only serves its local market and its supply chain will be self-sufficient and also locally minded. The theory of decentralized supply chains that is used in this paper is based on the work by Hadar and Bilberg (2012). To read more about the concept, please refer to their work. **Fejl! Henvisningskilden blev ikke fundet.** has been developed to show an example of how the European market could be divided into several decentralized supply chains. Notice that this example is not based on actual market data and therefore it is merely to show an example of how it could look like.

An analysis of sales could show that there is need for more local markets or that there is a need for less.

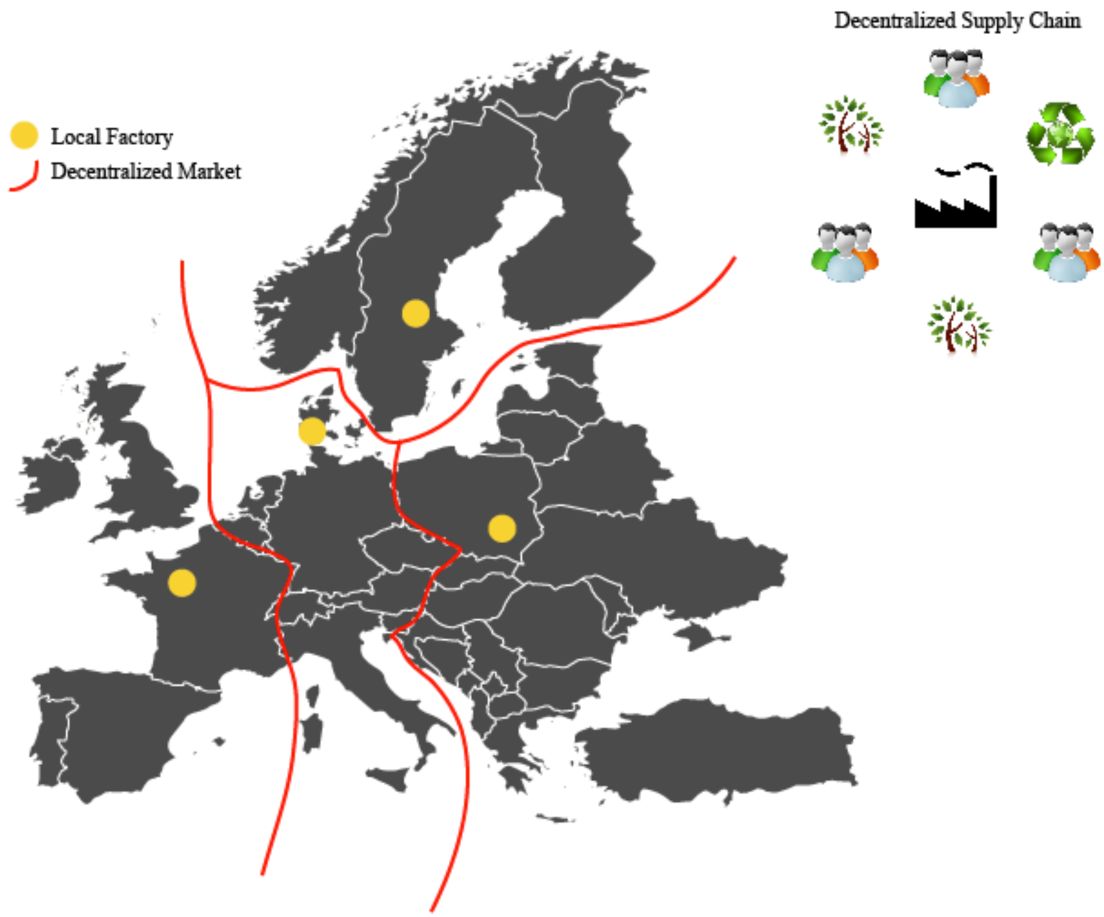

Figure 1 - An example of how a decentralized Europe can look

Only by completely separating the regions of the supply chain and create alliances with local partners, can manufacturers truly reduce its complexity and handle fluctuations in demand. By doing so, manufacturers will also be able to minimize lead times due to physical proximity to customers, operate on the bases of real-time demand with minimum inventory, and increase customization to their customer and consumer needs.

The factories must be intelligent and changeable. This means that the factory must be able to make seamless and rapid changes to its functionality, design and capacity. Potentially, the factory should be able to completely supply a specific market's needs while still taking advantage of economies of scale. The changeable property of these technologies will enable manufacturers to increase and decrease capacity to fit real time demand. Moreover, changeable technologies present opportunities to satisfy consumer needs in regards to customization and personalization of products.

The decentralized supply chains will bring the manufacturer closer to the customer and to the consumer. Being closer is not only a benefit in the sense of distance but also when thinking about products and marketing. It is argued that it is important for global manufacturers to act locally (Prakash & Singh, 2011). Further is it emphasized that the globalization of a product will only succeed when the product is adapted specifically to the local environment. Glocalization is a hybrid between globalization and localization that provides benefits from both worlds (Gustavsson, Melin, & Macdonald, 1994; Prakash & Singh, 2011; Sarroub, 2008). The next level of decentralization will be to glocalize factories by producing global products that are localized to be adapted fully in the local market. It is important that both suppliers and partners also operate on a glocalized structure in order to fully complement it and make the entire supply chain responsive and flexible.

The authors believe that such a setup will be able to solve the challenges that LEGO are facing in the current supply chain. It is also believed that this will be the case for other manufacturers working in global supply chains.

The new supply chain

Now that the concept of decentralized supply chains has been introduced it is possible to apply the theory to LEGO. In the case study the challenges that the manufacturer is facing with its supply chain were identified and in the following the decentralization concept will be applied to see if it can potentially solve them.

The new supply chain must be capable of adapting to changes quickly; hence responsiveness is of high concern. One way to increase responsiveness is to **produce according to actual demand** instead of producing according to forecast. To do so, the decoupling point of the company in question must be located early in the production process. In other words, the differentiation of products needs to occur as late in the process as possible. This requires that the lead-time of the production and delivery is shorter than the time that the customer is willing to wait for it. As mentioned before, changeable factories can aid in this matter.

One of LEGOs challenges was the wish to decrease inventory levels. **By bringing all production processes together in one facility, inventories between the processes can be decreased substantially**. A main idea of the decentralization is to replace the global setup of DCs; in the decentralized setup **there will no longer be a need for a DC**, as finished products are shipped directly to the customer, **which will drive down the inventory** even further. The new decoupling point will be located before the production, and hence the production will be based on a Just In Time, pull environment with **no need for inventory between the processes**. This leaves only one inventory: raw materials. The authors prescribe that suppliers are capable of delivering raw materials from day to day. This will make it possible for the manufacturer to keep the **lowest possible inventory of raw materials**. The only inventory that will be left is the exact amount of raw materials that is needed for the order(s) that is being produced. It was found that LEGO had already gone through an early decentralization of their production. With this, they found that their inventories had decreased, which backs up the argument that decentralization will not only decrease but also minimize inventory levels. It is important to notice that there should still be a coherency in the choice of suppliers, since standardization of quality between the local factories (LF) is of high concern. Furthermore, the one on one relationship with suppliers and distributors should be sustained. This means that these should also utilize a decentralized supply chain.

Forecasting was found to be a challenge due to the seasonality factor of LEGO’s products. As mentioned before, the LF will utilize a make-to-order principle and thus **forecasting will not be a challenge anymore**; products are only produced when there is an actual demand for them. For this it is important that the LF is capable of ramping up and down over the year.

Furthermore was it found that materials, WIP and finished products were transported over great distances and that this increased transportation costs. In the decentralized supply chain, the production processes will be located close to the customer, thus the distance that products need to travel will be shorter. Even more important, **the transportation of WIP between facilities can be avoided fully**, since all the processes are now located within the same facility - the LF. Material flow between facilities in different markets will not be present either as they are all capable of handling all production processes and because they are completely self-sufficient. This will also help to **decrease the complexity of the supply chain**, which also is a challenge that is being faced by LEGO.

In light of the above, *Figure* ***2*** has been developed, which visualizes the suggested new supply chain for LEGO. With this setup, the flexibility of the production has been increased significantly and furthermore has the responsiveness of the full supply chain been increased. In *Figure* ***2***, the new supply chain for the manufacturer can be found. Before, it took three months to deliver a product that was not in inventory and with the new supply chain this has been **brought down to seven days.** The reason is that the production **lead-times have been decreased** by utilizing the changeable production technology and that the supply chain is shorter now that some steps can be left out. What have been left out are the DC, and other inventories that were used to keep the delivery time low.

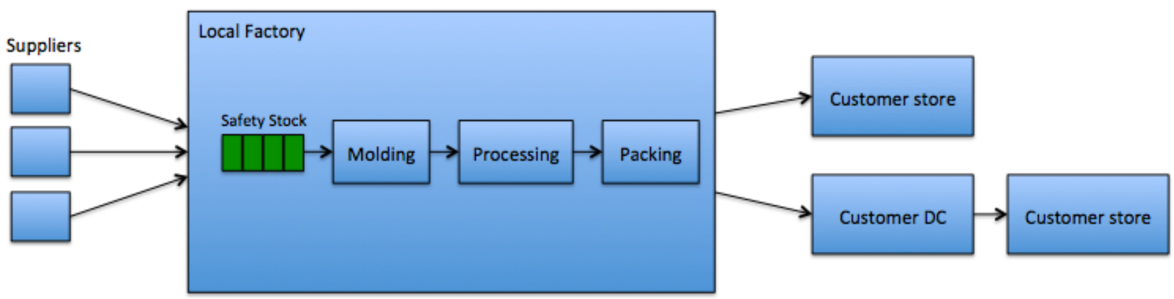

Figure 2 – The suggested new supply chain for LEGO

Conclusion

It was found that a decentralization of LEGOs supply chain will allow great flexibility and responsiveness and in addition, lower their lead times because of the shorter distances travelled. The overall complexity of the supply chain will also be decreased substantially, because the material flow has been minimized or even avoided. This also helps to bring down the lead-times. The authors believe that this concept can be implemented in other companies with the same positive effect.

It was found that the concept of decentralizing the supply chain will also drive down inventory levels to a minimum due to the fewer inventories needed. The production is based on producing to actual demand instead of producing to a forecast, which will also bring down inventories. The most expensive inventory to hold is finished products and by leaving out the DCs the savings are abundant.

Since the production volumes will be focused to a smaller market, companies should avoid special purpose machines, and instead go for more changeable and reconfigurable manufacturing processes and equipment that can maximize production flexibility and enable the possibility to fulfill local and customer specific demand. Utilizing changeable factories will decrease the production lead-times further.

Those who wish to employ a decentralization of their supply chain should start identifying their markets by analyzing their sales. Once this has been done, the supply chain needs to be redesigned to utilize the decentralization concept. The LF must be developed in order for the production processes to fit with the new supply chain. It is important that the time it takes to receive, make and deliver an order is shorter than the time the customer is willing to wait for it.

An interesting area of future research is the costs associated with running additional factories. When building the new LFs the additional costs of running and administrating these must be considered. The structure of the new factories is very different than the structure we have today. The new structure will be a network of smaller and more intelligent factories, which potentially could cost less than these today. The substantial savings from decreased inventories and scrapped DCs will make the savings even greater. Another interesting area to research further is the issue of standardization across the LFs, which should be of high concern to any company wishing to engage in the concept. More research areas for the future would be to look into the size of the decentralized market, and what this do to the organization and the homogeneity of the company in, for example, R&D, marketing and sales.

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