A supply chain strategy for an innovative commodity producer: Testing the applicability of established theoretical models

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Abstract

The distinction between innovative and functional products have for more than a decade been central to our understanding of how to design appropriate supply chains. However, the distinction between the two types of products, and the associated "optimal" supply chain, are blurring, as high competition forces commodity producers to move up the value chain and increase the innovative content of their products. The purpose of this paper is to use a single case study to test whether established supply chain models can be applied to an innovative commodity producer. The paper finds that although some established model still have merits, a supply chain strategy cannot only be based on product characteristics. Factors such ease of transport and uncertainties in materials supply needs to be taken into account and an effective supply chain may involve utilising decoupling point to combine the benefits of both efficient and responsive supply chains.

Keywords: Supply chain strategy, Steel industry, Case study

Introduction

Questions regarding logistics in general and supply chain management in particular, have become important strategic issues for companies. A well-adjusted supply chain strategy can generate an increased turnover, decreased costs and increase overall efficiency within an organisation (Christopher 2000; Fisher 1997; Qi et al, 2011). However, determining which aspects that affect a supply chain, and therefore should be considered when designing a supply chain strategy, can be problematic for any supply chain manager at any company. Fisher (1997) and Christopher and Towill (2002) suggest that product type is the main factor that determines which supply chain strategy to implement in an organisation; either a lean/efficient or an agile/responsive supply chain. Furthermore, both Christopher and Towill (2002) and Qi et al (2011) point out that that, in some cases, it is preferable to combine the lean and agile strategies. The idea of combining strategies could be done by introduce decoupling points in supply chains where different strategies are used before and after the decoupling points (Naylor et al., 1999).

Companies that try to analyse their operations according to Fisher's (1997) and Christopher and Towill's (2002) models might experience problems since the theories and models tend to simplify reality too much (Lee 2002; Selldin and Olhager 2007). Hence, there is reason to question theories behind product based supply chain strategies and their applicability. And the fact that Fisher' (1997) and Christopher and Towill's (2002) conclusions are based mainly on observation within retail industries, that generally have uncertain demands and short product life cycles. In order to test the applicability of their theories, the researched case should have the opposite characteristics; even demand and long product life cycles. The steel industry fits this description. Moreover, a relatively high degree of innovation would provide further insight into the applicability of the theory.

The purpose of this study is to test the applicability of product based supply chain strategies on the steel industry and its specific conditions. Although steel can be thought of as a highly standardised product, even a commodity, the selected case company, Sandvik, also scores high on innovative content, as it is ranked number 74 on Forbes list of the world's most innovative firms (Forbes, 2013). This is a higher rank than any other steel producer in the world. One of the units, Distribution Services within one of the corporate divisions, Sandvik Materials Technology (SMT), was selected. Distribution services (DS) role is to distribute steel tubes, tube fittings and flanges from the production unit in Sweden to customers throughout the world. The products have particularly high quality standards as they are often used in the off-shore oil industry and in nuclear power plants. The assortment that DS is offering is considered to be the standard assortment of SMT and hence, the study has been delimited to these products.

While supply chain management can be said to consist of three main areas; purchasing, production and distribution (Tseng et al. 2005), this study treats the concept a bit different. *Supply chain* includes production, storage and distribution, but not purchasing of raw material. Production is narrowed down to production lead times and internal materials supply while storage regards finished goods storage strategies and the structure of stock keeping units (SKU). Distribution regards transport solutions and transport lead times.

Theoretical Framework

According to Fisher (1997) the optimal supply chain demands that the products of the company are categorised as either *functional* or *innovative*, and depends on the product life cycle, Contribution margin, Product variety, Average error in forecast, Average end-of-season markdown and Lead time for made-to-order products. Lee (2002) exemplifies functional products as basic clothing, basic foods, oil and gas. Innovative products are often tailored for the final customer and can be computers, fashion articles and cell phones (Lee 2002). For functional products, Fisher (1997) means that an efficient supply chain is required, while innovative products require a responsive supply chain. The main purpose of an efficient supply chain is to supply a predictable demand as efficiently and cost effectively as possible. The responsive supply chain, however, is used for unpredictable demands and aims to minimize stock outs, price cuts and surplus of unwanted products.

However, there are additional aspects to consider besides the character of the product when designing an optimal supply chain strategy, and studies criticising Fisher (1997) have been presented by Selldin and Olhager (2007), Lo and Power (2010), von Haartman (2012) and Lee (2002). Lo och Power (2010) and Lee (2002) claim that the division between functional and innovative products is too sharp and that, in reality, many products are actually both innovative and functional. Furthermore Lo and Power (2010) mean that product complexity, uncertainty in material supply and where in the product life cycle the product is situated are also fundamental aspects when deciding which supply chain strategy is most suitable. Of these aspects, uncertainty in material supply is something that Lee (2002) focuses on, since a reliable production is a prerequisite in order to keep costs down and efficiency up when dealing with functional products.

Another aspect missing in Fisher's (1997) work is the dimension of products and the affect this has on transports. According to Tseng et al. (2005) different types of products require different transport solutions, which very much affects a supply chain strategy. For example, air transportation is recommended for products with short life cycles that need to reach the markets quickly; aspects that characterise a responsive supply chain according to Fisher (1997). Train transportation, however, can handle big volumes while road transports are flexible and are capable of reaching remote destinations (Tseng et al. 2005).

Selldin and Olhager (2007) on the one hand, show that companies that do match their products with their supply chain strategy generally achieve better results than companies that do not, with regards to price competitiveness as well as speed and certainty of delivery. However, Selldin and Olhager's (2007) study also showed that only 68 out of 128 respondents were able to categorise their products and supply chains according to Fisher's (1997) model. Furthermore it was shown that some companies were not able to create an optimal supply chain due to lack of influence over the supply chain structure . Von Haartman (2012) shows that companies that supply very innovative products, have some older products that have characteristics that resemble functional products, with far reaching consequences for the supply chain.

Table 1 – Product characteristics according to Fisher (1997) and Christopher and Towill (2002)

Christopher & Towill(2002	**Fisher (1997)**
Product	Product life cycle Profit margin Product variation
Demand	Forecast error Stockout level Seasonality
Lead time	Made-to-order lead time

Christopher and Towill (2002) argue, like Fisher (1997), that the categorization of the company product range is an important variable in the design of an optimal supply chain strategy, but instead of using *functional* and *innovative* they use the categories *standard* or *special*. Christopher and Towill (2002), however, offer no model for how to categorize products but merely give definitions to different product types, but a supply chain strategy is not dependent on the nature of the product alone. Other important factors are production lead-time and demand. Christopher and Towill's (2002) theory results in a three-dimensional model that generates eight possible scenarios, and depending on these three factors (product, lead time and demand), firms will need to apply an agile, lean or an adaptive supply chain. Christopher and Towill (2002) also point out that not all of these scenarios actually occur in practice.

Although Christopher and Towill (2002) base their choice of supply chain strategy on the aspects of product type, demand and lead time, they consider similar aspects but choose to present it differently compared to Fisher (1997). Fisher (1997) means that demand and lead-time are product characteristics while Christopher and Towill (2002) argue that product type, demand and lead-time are three separate aspects that together influence the choice of supply chain strategy.

Christopher and Towill's (2002) lean supply chain largely corresponds to Fisher's (1997) efficient supply chain while the agile supply chain corresponds to a responsive supply chain. The adaptive supply chain allows for use of both lean and agile strategies depending on what is best in a certain situation or a certain time in the supply chain (Christopher and Towill 2002). If cost is a market winner a lean supply chain is suggested because this type of supply chain contributes to high efficiency and reduced waste. However, if lead-time is a market winner an agile supply chain is required allowing for quick adaption to market requirements and products availability at the right time (Christopher and Towill 2002). Naylor et al. (1999) use the term *leagility*, that can be compared with Christopher and Towill's (2002) *adaptive* supply chain, and argue that lean and agile supply chains can be combined by means of decoupling points. The decoupling points divides supply chains into agile and lean sections, where lean is used upstream of the decoupling point and agility downstream towards the customer. The position of the decoupling point depends on the longest delivery time a client can accept (Naylor et al. 1999). One advantage of move the decoupling point further up the chain (towards production) is that the actual demand is visualized earlier and less buffer stock is required (Naylor et al. 1999). However, this action also extends the lead-time to the customer.

Case studies in the steel industry, with respect to supply chain strategies, are rare but in a study by Potter et al. from 2004 an English supply chain that handles steel products is described. The steel producer produced steel in large volumes and with long lead times for a stockholder and distributor, who in turn sold small quantities with short delivery lead times to the end customers. This way of producing required a forecast-based production with large stocks. This type of supply chain structure is common among steel companies in the UK according to Potter et al. (2004).

Methodology

The study was conducted as a case study and the data collected was of a qualitative nature which helped to gain an increased understanding of DS complex organization (Murray and Hughes 2008; Biggam 2011; Eisenhardt 1989). Features of the study were planned, implemented and documented in a structured manner in order to achieve the most reliable results possible. All documents were stored and updated as new discoveries were made or new conditions for the study were identified. The arguments in this research are based on an abductive reasoning since there was reason to believe that the theories in question possibly lack applicability. By trying to apply the theories on an industry selected by certain criteria these insufficiencies would be revealed.

A steering committee, that consisted of four employees from SMT with strategic positions; business unit manager for DS, Supply Chain Manager for DS, Supply chain operation DS and SMT Manager for Logistics Europe, Middle East and Africa, was appointed. In total, five meetings were held with the steering committee. All members could not be present at all times but each member was briefed of the meetings in advance and had the possibility to express constructive criticism via another committee member or other means of communication. The primary data comes from interviews and discussions with the steering committee. Secondary data consists of product information collected from the company website but also internal material such as power points and organizational charts provided by members of the steering group. Triangulation was applied in order to increase validity (Jick 1979).

Interviews were based on an interview template that was sent in advance to the respondents. The template was of semi structured, it consisted of open but standardized questions, in order to create a nuanced picture of the business and to be able to point out differences in responses from the interviewees. Each interview was recorded and the recording was analysed afterwards in order to minimize misinterpretations. The committee was chosen since they had deep knowledge of the organisation and a genuine interest in the project. The answers that emerged from the interviews can, however, not be traced to a specific individual. This is to assure the interviewees about their privacy and generate more honest answers. Respondents were guaranteed anonymity and also offered the opportunity to read through the results before it was published.

The analysis was carried out in three different phases: The first phase involved the categorization of DS products by using the theories and criteria for categorization that were available in the research of Fisher (1997) and Christopher and Towill (2002). The categorization formed the basis for a discussion on whether the theories are applicable in the steel industry. The second phase was comprised of a comparison between DS own approach, applied at the time of the case study, and the theoretically proposed supply chain strategies. The comparison made it possible to highlight the similarities and differences between practice and theory and laid the basis for discussion whether the strategies proposed by Fisher (1997) and Christopher and Towill (2002) can be considered reasonable to apply to the steel industry. In the final stage, aspects that the theories highlight as important when choosing supply chain strategy were compared with aspects that DS must take into account when designing an optimal supply chain.

The case of Distribution Services supply chain

"Sandvik Steel" is known in the industry for high quality, and they provide advanced stainless steels such as duplex, super duplex and sanicro materials, materials that are hard, strong and resistant to corrosion and erosion. The product range consists primarily of tubes, but even additional products such as pipe fittings and flanges. The tubes are used particularly in the aerospace and automotive industries, the nuclear industry and the oil and gas industry. The applications place high demands on safety and quality, including certificates guaranteeing good quality and that the products should be traceable back to the original steel melt. The tubes are of varying length and diameter, 6 meter lengths are common and the diameter ranges from about 3 to 300 mm. When a customer buys a tube there are several optional features such as custom lengths, bevelled pipe ends, colour labelling or special packaging. The pipe dimension makes them awkward to handle and reduces the choice of freight forwarders and transport solutions. All tubes are seamless since they are hot-pressed between a pad and a device that prevents the formation of joints and increases quality.

Sourcing & Logistics and Facility management (hereafter referred to as SMT logistics) is another part of the SMT group that is of interest for this case study since it functions as a central logistics department. The responsibilities of SMT logistics include warehousing and distribution of all products, which means that the DS are not doing any physical transport, but hire SMT logistics for this purpose. DS is a sales and marketing function responsible for managing standard deals. DS have no own production but are supplied by the joint production capacity of the company. The idea behind this approach is based on the notion that the DS core businesses are marketing, availability and sales, not production. Competitors uses largely external distributors, wholesalers or agents for the sale of corresponding products. Having a business unit structure like DS in SMT's organization, as opposed to an external wholesaler, is a strategic choice. It enables SMT to create and maintain good relationships with customers, which contributes to long-term sustainable business. DS supply chain has different configurations depending on different scenarios and the relationship between DS and SMT can be likened to a chain of external actors since they buy and sell products from each other. A common variant of DS supply chain is shown in Figure 5; note that all assets are shared with other business units

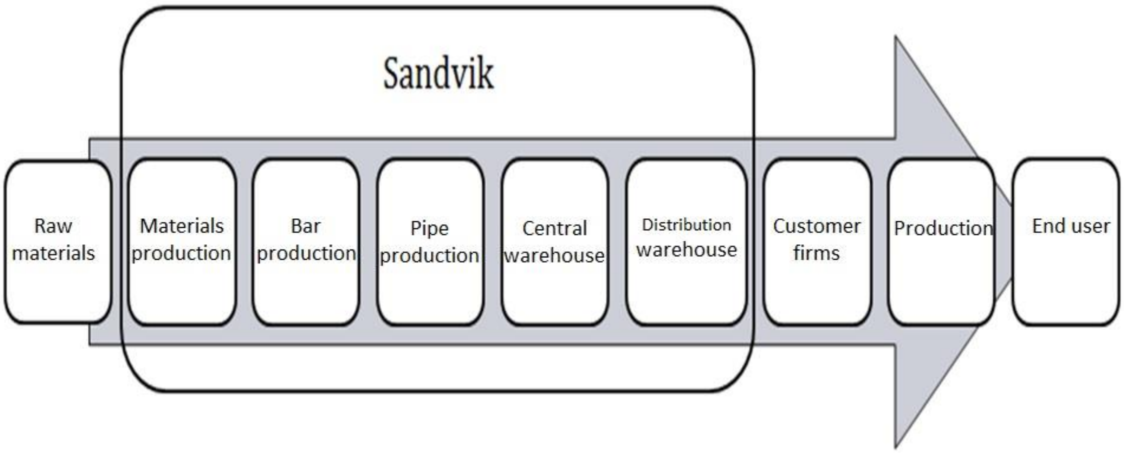

Figure 1 - DS supply chain (The parts are owned and shared by other business unit)

DS mostly produce to stock while the other BU’s usually produce to customer orders. Production capacity is, as mentioned earlier, shared by all BU’s within PA Tube. Since DS products have lower profit margins, a consequence of the shared production capacity is that other units are often given priority in cases where the capacity is not enough for everyone. DS cannot always rely on getting sufficient production capacity to support their customers' demand. The effect of this is that DS at times have had to refrain from some customers' needs and instead prioritize key customers. If DS organisation is to be perceived as trustworthy by the customer, however, they must be able to deliver irrespective of the internal situation. In order to solve this, issue a production allocation model within the PA Tube is now being implemented. If DS sells more products than PA Tube’s production can supply them with, it is possible to buy products externally. It also occurs that DS purchases products from outside suppliers if they are able to acquire products at lower prices than normal, or to complement the range of products that PA Tube is not producing.

The central warehouse is located in Sweden and the three distribution warehouses in England, Italy and the Netherlands. In addition to supporting distribution centres with products the central warehouse also delivers stock directly to customers in Scandinavia and other global markets. The warehouse in England and Italy mainly supply their national markets, while Netherlands supplies other countries in Europe , Middle East and Africa. SMT logistics plan the transportation to distribution warehouses and transfer points within Europe. This is done according to fixed schedules and routes. Delivery time to Europe on stocked products is about 1-3 days.

The market is not trend-sensitive, seasonality is virtually non-existent and the products have long lifecycles (about 20 years.) There are several competitors but with its clear niche for advanced and stainless steels, DS distinguish itself from most potential competitors. The market is changing, however, and companies with advanced steel in its product portfolio are more numerous today than ever. DS, which sells most of its products through the warehouse, normally keeps about 1,000 self-manufactured items in stock. Stock out is estimated to be about 10-15% and the margin of error in forecasts about 30%. Keeping stock allows DS to offer short delivery lead times.

DS customers buy directly from the central warehouse or from one of the distribution warehouses in Europe, but it is also possible to add orders straight to the production units. Usually DS does not deliver to an end user but to a company looking to process the products further or use tubes as components in their own production. The item can be sent directly from the warehouse to the customer but must sometimes be processed further, for example if the customer has ordered colour marking or bevelled pipe ends. Third party distributors, on behalf of SMT Logistics, handle the physical shipments from warehouses to distribution centres, and from distribution centres to the customer.

The following bulleted list summarizes the most distinctive opportunities for DS:

- Strong brand
- Heavy and long products
- Expensive and quality products (niche)
- Long product life cycles (20 years)
- Standard products
- Relatively stable demand
- Uncertain material supply
- Long production lead time
- Short delivery time (lead time to customers from stock)

Discussion

DS products are estimated to have a life cycle of about 20 years (functional) and the profit margin is typically around 10% (functional). Product variety is neither low or high, but depends partly on how you interpret the term *product category;* the 1,000 products that DS have stocked are all included in the same product category (tube), which would mean that there are a total of 1,000 product variations. However, these 1000 versions are of standard size and can be varied further with optional features such as colour coding and bevelled pipe ends. Therefore, it is interpreted that the product variety is medium (neither functional nor innovative). The margin of error on current forecasts is estimated to 30% (neither functional nor innovative). DS has an approximate stock out of 10-15 % (innovative), which can be considered high given that they argue they have a steady demand. The stock outs are very likely due to the uncertain material supply from internal production. Seasonality is basically unheard of (functional). Made-to-order lead-time is estimated at 4-12 weeks and it varies depending on how much material is in between different stock keeping units within the production site (neither functional or innovative). Categorization of DS products according to Fisher's (1997) product classification is thus problematic and in this case and cannot be used a a basis for selecting an appropriate supply chain strategy (see table 2). The finding is in line with Selldin and Olhager’s (2007) study, which showed that only 68 of 128 companies could categorize their products according to Fisher (1997).

Christopher and Towills (2002) theory was applied to conditions of DS. It is not entirely clear which lead-time that is considered, but in this study it has been interpreted as it is made-to-order lead-time; i.e. production against customer order. The authors provide a large room for interpretation in terms of the type of product you have, standard or custom. In this study, standard was considered as the equivalent of Fisher's (1997) functional product, while special products are the counterpart of innovative products. It is possible to apply Christopher and Towills (2002) way of categorising on DS and the result is that DS should manage their standard products, with relatively predictable demand, in a lean supply chain. The fact that Christopher and Towill's (2002) way of categorising is possible, but not Fisher's (1997), despite their similarities, has probably to do with Christopher and Towills (2002) three-dimensional presentation of the aspects. This way of presenting makes it possible to weigh the aspects of *demand*, *lead-time* and *product* separately, which is not possible in Fisher's (1997) case.

Table 2: Categorising DS products in accordance with Fisher (1997)

	Functional		***Innovative***
Product life cycle	X		
Profit margin	X		
Product variation		X	
Forecast error		X	
Stockout level			X
Seasonality	X		
Made-to-order lead time		X	

Another perspective of Christopher and Towills (2002) theory is the market winner criterion. Whichever criterion must be achieved in order to become a market leader requires different types of supply chain strategies. If *price* is the main criterion for becoming a leader lean strategies should be applied. If instead it is *availability* that is the primary criterion agile strategies should be applied. In DS' case since their competitive advantage is *quality*, but refers to an order qualifier, whereas availability and price are actually the order winners. Availability can be considered more important than price in the case of DS, as they compete with short lead times which, according to Christopher and Towill (2002), requires an agile supply chain strategy. This however, makes Christopher and Towills (2002) theory a bit contradictory since it was possible, through categorising, to state that a lean supply chain strategy was the most appropriate. However, they argue that a combination of lean and agile in some cases is beneficial and DS situation may be such a case. Christopher and Towill (2002) are not clear when to apply an adaptive supply chain.

In PA Tube's production cost elimination and efficient manufacturing processes are pursued and it has therefore been interpreted that they apply lean/efficient-like strategies. Production lead-time is between 4 to12 weeks but the lead-time from warehouse to customer is 1 to 3 days. Since one of the selling points is *quick delivery* a stock of finished goods is required so that delivery can take place as quickly as possible after the customer places an order. This, of course, demands accurate forecasting in demand and production. The transport from warehouse to customer uses agile/responsive-like strategies because of the need for flexibility and high customization. Despite a steady demand, DS sales volume shift quite sharply because of priorities between different BU's within PA Tube. This means that DS must be able to adapt their sales in favour of other BU's sales forecasts and actual sales volumes. In addition, DS keeps their customers close via sales offices in several locations in Europe, partly in order to get key customers to return to the business, but also to assist the customer when necessary. This way of maintaining high customer service is similar to the reasoning of Wouters (2004) that customer care is in part about offering customers an optimal buying process. Finally, DS offers different customized options for their products in order to able to offer a greater product range.

The combination of a lean/efficient production and an agile/responsive distribution makes it possible to argue that DS supply chain is adaptive (Christopher and Towill 2002). Fisher (1997) has no equivalent strategy but argues that an efficient or responsive supply chains are the only options. Naylor et al. (1999) describe more clearly how a combined supply chain functions where decoupling points act breakpoints in a supply chain. DS decoupling point is the central warehouse and splits the operations into two parts, where lean is used upstream of the decoupling point and agility downstream towards the customers. The location of the decoupling point depends on the prevailing conditions, lead times and delivery time conditions (Naylor et al. 1999). As the production lead-time is between 4-12 weeks and the lead-time from warehouse to customer is 1-3 days; the decoupling point in DS supply chain seems a natural choice. The warehouse makes it possible to stock products and sell on short lead times. Moving the decoupling up in the chain would be possible if production lead-time was shortened considerably.

Conclusions

Categorizing steel industry products according to Fisher's (1997) theory is not possible. Seven criteria must match in order for a product to be considered either functional or innovative, but the products investigated at DS have characteristics that are both functional and innovative. Christopher and Towill (2002) are not entirely clear about the aspects that characterize a standard product or a special product. With this in mind, one should, when talking about product characteristics, define what this means and what characterizes a particular product type. Christopher and Towill's (2002) model for the choice of supply chain strategy can, however, apply to the steel industry because it is three-dimensional. Thus, demand, lead-time and product type are treated as separate aspects. Thus, Christopher and Towill's (2002) model appear more plausible as aspects do not necessarily have to affect, or exclude, each other. Christopher and Towill's (2002) theory also highlights the market winning criteria as an influential factor and their separation between lead-time, demand and product characteristics makes the application of their theory on DS simpler. However, in DS case there are also other aspects that need to be taken into account when trying to achieve a competitive business strategy. Christopher and Towill's (2002) model also has limitations.

The study also shows that DS applies a supply chain strategy that is a combination of efficient/lean and responsive/agile. Fisher (1997) presents no supply chain strategy in line with this, which means that even here, Fisher's (1997) theory is not applicable to the steel industry. Christopher and Towill (2002) however, present the adaptive supply chain which is found in DS where lean and agile strategies are combined. A decoupling points, as presented by Naylor (199), has been utilised in order to combine efficient a responsive supply chains.

The conclusion of this study is that a supply chain strategy in the steel industry cannot only be based on product characteristics. A supply chain manager in the steel industry must identify the factors within the business that are significant in the choice of supply chain strategy. More aspects can be added to the analysis, such as products physical dimensions, transportation solutions and uncertainties in materials supply. An analysis will help to generate a realistic image of the business and thus may also assure that the optimal supply chain strategy is chosen, whether the strategy is a combination of agile/responsive and lean/efficient strategies, or not. If a combination of strategies is found to be suitable, an analysis can also help to determine where in the supply chain the decoupling point should be placed, depending on what is considered most important; short lead times or cost-effective production, or both.

Some findings should be investigated further. The product categorization that Fisher (1997) and Christopher and Towill (2002) present should be developed and concretized (in Christopher and Towill's case) and made more applicable to other industries than retail. Other aspects not directly related to product characteristics, but which are of importance to the choice of supply chain strategy, should be explored further. It may be of particular interest to examine product dimensions and their impact on transport further.

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