THE ROLE OF MATERIAL DECOUPLING POINTS IN SHAPING THE PRODUCT OFFERING OF SUPPLY CHAINS

Natalia Szozda, Department of Logistics, University of Economics, ul. Komandorska 118/120, 53-345, Wroclaw, Poland, +48 71 36 80 334, natalia.szozda@ue.wroc.pl

Artur Swierczek, Department of Business Logistics, University of Economics, ul. Bogucicka 14, 40-007, Katowice, Poland, +48 32 2577302, artur.swierczek@ue.katowice.pl

ABSTRACT
The paper seeks to reveal the link between the concept of material decoupling points and the specific levels of product in supply chains. Based on supply chain management literature concerning the prerequisites of the location of material decoupling point and marketing theory of the total product concept, we argue that there is a relationship between the specific positions of material decoupling point in supply chains and the levels of product offering addressed to the consumer. This theoretical proposition is largely confirmed by the analysis of survey responses collected from 231 of European supply chains operating in various industries. The paper contributes to combine the internal operations performed in supply chains with the marketplace requirements of consumers. The findings of the paper provide theory-driven and empirically evidenced explanations for supply chain managers seeking to enrich manufactured and delivered products with the appropriate operational instruments.

Keywords: decoupling point, total product concept, supply chain

INTRODUCTION
The concept of material decoupling point is one of the most talked about topics which has been on the supply chain research agenda for several years [1] [2] [3]. In general, the material decoupling point separates the customer order part activities from the operations which are based on forecasting and planning [4]. In this vein, it coincides with a major stock point in a supply chain. The stock in the material decoupling point may take a different form ranging from a conceptual idea and project, through generic structure of semi finished goods to the physically ultimate form of product. Consequently, the product may be enriched with the specific attributes at each level of physical flow in supply chains, and thus adapted to the refined requirements of final customers. The expectations and desires of ultimate customers may be expressed with the marketing concept of total product which highlights different levels combining tangible and intangible components of a product. This concept is also used to indicate the sources of competitive advantage and demonstrate the levels of market rivalry at a strategic angle.
In order to obtain greater insights in the area, a study was undertaken to examine the link between the locations of material decoupling point and the specific levels of product offering in supply chains through a quantitative research approach. The study makes important contributions by:

- attempting to build a bridge amid different fields of knowledge through seeking a correspondence between the supply chain concept of material decoupling point and the marketing theory of the total product;
- taking advantage of an in-depth look at managers’ perspective on the location of material decoupling point and its role in shaping supply chain product offering;
- developing a conceptual framework of a relationship between the locations of material decoupling point and the levels of offered product.

The remainder of the paper is structured as follows. Following the introduction, the concept of material decoupling point was discussed. Then, theoretical background of the marketing total product was described. In the next part of the paper, research framework and methodology was developed. Consequently, empirical findings derived from statistical analysis were reported and discussed. Finally, conclusions of the research were drawn and the implications for further empirical studies were highlighted.

THE CONCEPT OF MATERIAL DECOUPLING POINT IN SUPPLY CHAINS

The concept of material decoupling point determines a position in the product axis to which the customers’ order penetrates. It is where order driven and forecast driven activities meet [5]. In other words, the material decoupling point is a buffer between upstream and downstream players in the supply chain. This enables them to be protected from fluctuating consumer buying behavior and therefore establishing smoother upstream dynamics, while downstream consumer demand is still met via a product pull from the buffer stock [5]. Figure 1 illustrates the typical positions of material decoupling point in a supply chain, namely engineer-to-order, make-to-order, assemble-to-order, delivery-to-order, make-to-stock.

The first location of material decoupling point denotes that the products are specially designed from engineering specifications. While they might use some standard components, at least some of the product elements or arrangements of components have been specifically designed by the customer himself or the customer working with the specific supply chain link, mostly manufacturer. The next make-to-order allocation of the material decoupling point is characterized by raw materials and components which are common but can be configured into a wide variety of products. Similarly, in assemble-to-order system products can be customized within a range of possibilities, usually based upon a standard platform [6] [7]. Delivery-to-order denotes that the material decoupling point is located closer to the market (usually in a central warehouse or distribution center) and the shipment of the final product to the retailer is initiated when the customer order is received. If the material decoupling point is located in make-to-stock, the products are standardized but not necessarily allocated to specific locations; the demand is anticipated to be stable or readily forecasted at the aggregate level [8].
The appropriate position of the material decoupling point is a critical issue in each well-managed supply chain. Both the industries and particular supply chains are different and there are always some technological, organizational and economic limitations which constrain or enable to locate the material decoupling point in a specific position. Its location is also strictly interrelated to the major supply chain strategies of postponement and time compression of the physical flow of products. The first one determines a coherence between customers’ expectation and supply chain product offerings while the latter one ensures that the product or service is manufactured and delivered timely. Despite the fact that the material decoupling point can be located at different locations in a supply chain, there is a governing principle which says that it should be moved as close to the ultimate customer as possible in order to meet all his/her desires and expectations. From this perspective, it corresponds to the marketing concept of total product which highlights the role of specific attributes of product offering desired by consumer.

**THE LEVELS OF PRODUCT OFFERING IN SUPPLY CHAINS**

Supply chains offer the customers a product that is expected to provide tangible benefits, adequate to the market price. From the customer perspective, the value of product is defined as a balance between the benefits and the price [9]. The more benefits the consumer is able to obtain from the use of product, the higher price he is willing to pay for it. What may help in identifying
the structure of product and determining its usefulness is the total product concept, which creates a hierarchy of the value for the customer [10]. This approach can be linked to Maslow’s hierarchy of needs [11].

Two basic concepts of the total product are discussed in literature. The first one, developed by Levitt [12] in the 80s last century, distinguishes three levels:

1. core – the essence of the product, its functional features and some technical solutions;
2. actual product – everything, what has an impact on the perception of goods (services) by the consumer, i.e. brand, trademark, model, material, price, quality, packaging, style, as well as the appearance and behaviour of sales personnel;
3. augmented product – all additional benefits to the consumer, such as: delivery, warranty, complaints, spare parts, the availability of additional services, loan, instruction, installation, repair, etc.

![Figure 2. The three levels of the product by Levitt.](Adapted from: [12])

The second concept is the total product structure proposed by Kotler [10] – Fig. 3. The concept distinguishes five levels. The lowest level is the core product, which is the basic advantage, service or benefit which the buyer is actually purchasing. At the second level, the basic advantage is converted into a product in the basic form. At the third level - expected product, denotes a set of characteristics and conditions, which are usually required by customers purchasing the product. The fourth level is an augmented (improved) product which exceeds customer’s expectations. There is a potential product at the fifth level. It includes all possible improvements and transformations which the product or service may undergo in the future.
The main distinguishing feature of these levels is the share of material (tangible) and non-material (intangible) parts of the product [12]. Such a classification is mainly related to the organization of product flows. Therefore, the total product concept can be extended and considered not only in terms of marketing characteristics, but also in relation to the organization of physical flows among supply chain parties.

Table 1. Characteristics of the product levels

<table>
<thead>
<tr>
<th>Total product levels</th>
<th>Characteristics</th>
<th>Share of material and intangible parts</th>
<th>Areas responsible in a supply chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Product</td>
<td>Technical design</td>
<td>Pure material good</td>
<td>Research and development</td>
</tr>
<tr>
<td>Basic Product</td>
<td>Price</td>
<td>Pure material good</td>
<td>Production</td>
</tr>
<tr>
<td>Expected Product</td>
<td>Quality, packaging, style, appearance, brand</td>
<td>Service enriched material good</td>
<td>Production/Marketing</td>
</tr>
<tr>
<td>Augmented Product</td>
<td>Services: financial, designing, pre-sales, sales, after-sales</td>
<td>Material good enriched service</td>
<td>Logistics</td>
</tr>
<tr>
<td>Potential Product</td>
<td>Company's reputation, image, customers’ relationships with distribution channels and relationships between clients</td>
<td>Relatively pure service</td>
<td>All functional areas</td>
</tr>
</tbody>
</table>

Adapted from: [13] [21] [22] [23] [24]
As depicted in Table 1, the first two levels of product relate to its pure material characteristics. Therefore, in the context of coordination of physical flows in supply chains, it is reasonable to consider these two groups together [13]. At these product levels, it is important to organize a production process aimed at lowering costs. This is directly related to the optimization of processes and the introduction of lean management concept in order to reduce inventory levels. The following two levels: expected and augmented products constitute the transition into market orientation which highlights the importance customers’ needs [14]. In these product levels, an intangible part of product dominates and plays a significant role in achieving market success. For instance, the supply chain strategy of Apple is based on shaping the customer’s needs. The expected product extends the concept of cost minimization and concentrates on the appropriate quality management policy [15]. Another important feature at this product level is to consider the packaging as an additional feature. From the view of physical flow, it serves two important functions, namely product protection and carrier of information [16]. The augmented product level is enriched with additional services or benefits [17]. The key success factor at this level is logistics. The supply chains which distinguish this level as a pivotal product component in gaining and sustaining a competitive advantage are concentrated on meeting customers’ needs and expectations [18]. Accordingly, it is important to observe certain quality standards, which, in practice, are usually measured by the OTIF rate (on-time, in-full, error-free) [18]. It means that all purchased products were supplied without delay, and none of the products was damaged [19]. It is possible to achieve a high OTIF rate when pre-trade, trade and post-trade standards of logistic customer service are properly identified and defined [20]. At the level of potential product, the offer is entirely based on intangible qualities which are constituted by all improvements and transformations made to the product now and in the future [17]. Due to the intangible nature of these products, the prevailing share of the product offering is constituted by widely understood services, including marketing and R&D efforts.

**METHODOLOGY**

**Measures and sample characteristics**

In order to identify the role of material decoupling point in shaping the product offering of supply chains an exploratory study using a quantitative survey as a method of data collection was conducted. The main research instrument was a questionnaire consisting of several sections examining the location of material decoupling points and specificity of products manufactured and delivered in supply chains. The set of data collected within the release of the survey was gathered in Polish organizations. For the purpose of the research presented in this paper, a group of relevant variables has been selected. The first variable investigated the location of material decoupling points and consisted of five items measuring the percent of manufacturing orders falling into one of the following categories, namely engineer-to-order (ETO), make-to-order (MTO), assembly-to-order (ATO), delivery-to-order (DTO) and make-to-stock (MTS).
The second variable analyzed the groups of attributes which enrich the product offering of supply chains and may be classified into the following product levels: core, generic, expected, augmented and potential. It measured the percentage of specific attributes corresponding to the product levels which add the value to the whole product offering. The sample was compiled from the surveys of manufacturing and trading companies operating in supply chains, and consisted of 231 organizations. In the result of initial analysis, screening and elimination of observations with missing values, a group of 189 companies remained as a subject of further investigation. These firms were leaders or major links located upstream, in the middle or downstream in their supply chains. The structure of supply chains was established by at least three subsequent links.

The majority of the surveyed firms (58 percent) are trade companies, remainder of the research sample includes manufacturers. The prevailing share of companies operate in wholesale and retail grocery sector (15 percent), fabricated metal products, industrial and commercial machinery sector and manufacturing of motor vehicles (a total of 13 percent), followed by the companies from a mining industry (7 percent), trading companies (selling cross-industry products, mainly household goods – 3 percent, clothes – 2 percent, chemicals – 2 percent). The dominant share of 38 percent of the sample employed up to 9 people, followed by 30 percent of the companies employing from 10 to 49 persons. A smaller share of 18 and 14 percent of the sample belonged to the companies employing from 50 to 249 and above 250 people respectively.

Research outline and statistical analysis
For the analysis, the sample was classified into homogenous groups through cluster analysis. The criteria for classifying the sample into clusters were the five items manifesting the location of material decoupling points in supply chains. At first in order to determine the number of clusters a hierarchical cluster analysis with Ward’s partitioning method and squared Euclidean distance was performed [25]. In the result of the analysis five clusters were formed. The number of groups was obtained through the greatest increase in the agglomeration coefficient while minimizing a number of clusters [26]. The greatest increase corresponds to the grouping of all cases from five to four clusters. The number of five clusters was then used to perform K-Means Cluster Analysis to assign each case to the appropriate cluster. The criterion of the cluster membership was the minimal Euclidean distance between each case and classification center represented by centroid (cluster center). Additionally, the results of K-means cluster analysis were compared with a class assignment obtained from the hierarchical cluster analysis. On the basis of the results of two partition methods the contingency table was constructed and Rand index calculated. The measure of agreement showed that 82.7 percent pairs of objects are placed in the same class. It means a high level of agreement and confirmed a correct choice of K-means cluster analysis as the leading clustering method [27]. The outcome of cluster analysis provided the indication of the prevailing location of material decoupling points in five clusters - Table 2.
Table 2. The percentage of manufacturing orders manifesting
the location of material decoupling point

<table>
<thead>
<tr>
<th>The location of material decoupling point</th>
<th>Clusters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Enigeer-to-order</td>
<td>0.07</td>
</tr>
<tr>
<td>Make-to-order</td>
<td>0.18</td>
</tr>
<tr>
<td>Assemble-to-order</td>
<td>0.03</td>
</tr>
<tr>
<td>Delivery-to-order</td>
<td>0.69</td>
</tr>
<tr>
<td>Make-to-stock</td>
<td>0.04</td>
</tr>
</tbody>
</table>

The first cluster contains 17 percent of the research sample and indicates that the prevailing share of 69 percent of orders is delivered to order. It means that the supply chains in this group use delivery-to-order system to meet customers’ expectations. Cluster 2 includes almost 15 percent cases in the sample. The companies of the group report that the highest percentage of manufacturing orders (57 percent) are falling into engineer to order. Cluster 3 contains the share of 29 percent of companies in the sample. The dominant share of this group (81 percent) is characterized by make-to-order system. Cluster 4 includes the share of 30 percent of companies in a sample. This group reports that the prevailing share of orders (66 percent) is falling into assemble-to-order system. The last cluster 5 contains the smallest share of almost 10 percent of companies in the sample. Thought it demonstrates the highest share of orders falling into make to order system (24 percent), it is difficult to indicate an unequivocal conclusion for this group as there is no dominant category and the percentages demonstrating different locations of material decoupling point are mostly even in this group. The analysis of the fifth cluster revealed that the group is rather similar regarding the percent of manufacturing orders. Accordingly, it shows no specific tendency indicating the domination of particular location of material decoupling point. It suggests that all potential locations of material decoupling point in this group enriches the product offering similarly.

THE RELATIONSHIP BETWEEN THE LOCATION OF MATERIAL DECOUPLING POINT AND THE LEVELS OF PRODUCT OFFERING IN SUPPLY CHAINS – PRELIMINARY FINDINGS AND CONCEPTUAL CONSIDERATION

The distinguished clusters have been analyzed considering the levels of product offering in supply chains. In order to determine whether the supply chains are different regarding the location of material decoupling points ANOVA analysis has been performed. The four groups show significant differences (p<.01) in the five items (ETO, MTO, ATO, DTO, MTS) manifesting different locations of material decoupling point.
The findings demonstrate that the location of material decoupling point is linked to specific levels of product offering in the analyzed supply chains - Table 3.

Table 3. The comparison of the obtained clusters in terms of the levels of product offering (average percentage)

<table>
<thead>
<tr>
<th>Cluster no.</th>
<th>Location of material decoupling point</th>
<th>Levels of product offering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Core</td>
</tr>
<tr>
<td>1</td>
<td>Delivery-to-order</td>
<td>0.12</td>
</tr>
<tr>
<td>2</td>
<td>Engineer-to-order</td>
<td><strong>0.33</strong></td>
</tr>
<tr>
<td>3</td>
<td>Make-to-order</td>
<td>0.14</td>
</tr>
<tr>
<td>4</td>
<td>Assemble-to-order</td>
<td>0.21</td>
</tr>
<tr>
<td>5</td>
<td>Customer relationships-to-order</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Table 3 shows that the relationship between the locations of material decoupling point and specific levels of product offering may be revealed. The findings demonstrate that in the first cluster ‘delivery-to-order’ system enriches augmented product offering, ‘engineer-to-order’ in the second group adds the value of the core of a product, ‘make-to-order’ system in the third class improves the generic product whereas ‘assemble-to-order’ in fourth cluster ameliorates the expected level of products offering. The findings suggest that the enrichment of product offering in supply chains is determined by the location of material decoupling points. There is also a very interesting result obtained in the fifth cluster which enriches the potential product in supply chains. As all previously discussed potential locations of material decoupling point equally provide the value of the product offering we propose to refer the location in the fifth cluster to as a ‘customer relationship-to-order’.

Figure 4 illustrates the five locations of material decoupling point referred to the specific levels of product offering in supply chains.

Research findings indicate that apart from the activities within product flow, there are also regulatory and project activities which enable to enrich the product portfolio of a supply chain, and somehow supplement the portfolio in terms of concept and transaction.

From the perspective of a complete product, this means a necessity to include marketing, as well as research and development activities. This leads to distinguish between two extreme positions of material decoupling point, located outside the product physical flow. One of them refers to the core of the product and is related to the concept-related activities connected with designing products with the application of ETO (engineer to order) approach. The second location is characteristic for a potential product and concerns transaction-related activities consisting in shaping relationships in accordance with the individual expectations of customers. It is referred to with the acronym CRTO (customer relationships to order).
Fig. 4. The concept of specific locations of material decoupling point and their impact on the level of product offering in supply chains

Engineering-to-order consists in developing new products on the basis of individual orders from customers. A customer frequently participates in the process of engineering the requested product. The engineered-to-order products are characterised by a high level of specialization and a high degree of complexity. The volume of engineered-to-order products is low. The location of the material decoupling point in this area is justified in the case of delivering luxury products which meet specific requirements of customers, and the requirements related to products have been very precisely defined by purchasers. The volume of engineered-to-order products is low. This is due to the fact that they are usually luxury products which meet specific requirements of customers, and the requirements related to products have been very precisely defined by purchasers. Products are usually engineered to order in the research and development department, located in the leading link of a supply chain.

On the other hand, the location of the material decoupling point in the Customer relationships to order area enables to enrich the product of a potential supply chain. Therefore, it consists in forming relationships with a customer in accordance with his individual expectations. However, the subject of enrichment is not the product, but the relationships which connect the customer with a supply chain. Such relationships are facilitated by the involvement of a supply chain in the customer service process, focused on pre- and post-transaction elements, image, as well as
product and service brand identification. They constitute the basis for establishing firm relationships based on trust and involvement in the process of creating value for the customer and other supply chain stakeholders. The benefits of relationships particularly have the emotional and social dimension. The formation of relationships in accordance with the individual expectations of customers consists in the cooperation between companies in a supply chain towards developing positive relationships with customers, based on their satisfaction and emotional involvement.

Customer relationships to order enables to detach from the classic understanding of a product as a collection of benefits for a consumer and look at a products as a specific manner of meeting needs. It is about the semantic and symbolic layer of a product understood as a defined consumption pattern. Developing relationships with a customer also enables to define the improvements and transformations which the product and service range in a supply chain should be subject to in the future, so as to meet customer expectations in a better manner. Therefore, the CRTO material decoupling point in a supply chain has been located at the consumer level, in order to stress its primary role in the formation of appropriate relationships at the potential product level, as well as its significance in the development of the product and service range in a supply chain. In practice, it is hard to identify examples of individualization located at the CRTO point. This is due to the fact that this location concerns exceptional situations, involving products which are close to functional products in terms of the degree of range differentiation, but at the same time the appropriate formation of customer relationships is important.

An example may be the supply chain of Apple, which tries to develop relationships with customers at the potential product level (mainly by means of AppleStore, iTunes and additional user support), but at the same time the company offers relatively few options of individualization of its flagship product - iPhone. They include a pre-defined smartphone offer in certain colours and options of memory card capacity [28]. The given example confirms that a product which is equipped with a majority of features of an innovative product, may be at the same time relatively standard, which implies specific solutions in a supply chain.

The difficulties in finding practical examples related to the location of CRTO point are also connected with the character of the activities undertaken in the formation of relationships with a customer. The activities related to the first four decoupling points usually have a sequential character, that is, some of them follow the other, whereas the activities related to the formation of relationships with customers are undertaken together with the activities in the physical flow, rather than developed only upon the completion of product-related activities at an extended level. It may be assumed that the bigger individualization of a product and service range in a supply chain, the bigger the likelihood of establishing excellent relationships with customers upon completing the order and delivering the product. An extended order lead time as a result of a deeper location of the decoupling point, as well as the possibility of customer’s participation in creating the product and service range, allow for a bigger involvement of partners in relationships and help to build trust. This contributes to establishing long-term partner relationships between a supply chain and a customer. An example may be a supply chain which delivers luxury cars, whose customers may get special treatment after defining all requirements and individualized
expectations regarding the product. Thus, customisation at the potential product level may include invitations to parties, concerts of stars, individual presentations and testing of new luxury car models.

In the light of these considerations, the deeper the location of the material decoupling point in a supply chain, the bigger the possibility of having an impact on specific levels of complete product and the likelihood that the product may take individualized features. An additional argument for such perspective is the fact that as a rule, standard functional products should be available in the deliveries of a supplier located near the market and end customers. However, it shall be noted that the formation of functional products may occur both on the material and non-material layer levels [29].

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