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ANALYSIS OF MATERIAL FLOW IN A DISTRIBUTION NETWORK FROM THE PERSPECTIVE OF SELECTED LOGISTICS OPERATOR

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Purpose: The purpose of this paper is to analyze material flow from the perspective of a logistics operator operating in a distribution network at Material Decoupling Point (MDP). This analysis will focus on classifying the flowing products into the appropriate groups in terms of their sales characteristics, release volume and the value of the coefficient of variation. This analysis will also involve product classification in terms of forecast accuracy.
Design/methodology/approach: Main method used for the research focuses on analyzing one of distribution network. Analyze considered examination of material flow and tests of forecast tool to improve operational issues.
Findings: Logistics operator is able to forecasting demand of products in distribution network. It is interesting area of research developing in the future.
Originality/value Forecasting is considered here as a kind of development perspective for the operator who currently does not make forecasts. Forecasting implementation could be in these case

Keywords: distribution network, forecasting, logistic operator, material flow.

Category of the paper: Research paper, Case study.

1. Introduction

Product flow, as part of logistics systems, contributes directly to customer satisfaction. The last stage of building satisfaction and managing product flow is distribution. Therefore, it can be concluded that distribution focuses mainly on providing buyers with the products they desire in the destinations where they want to purchase them. Products should be delivered in a timely manner, on agreed terms and at an acceptable price. Distribution goals focus on sales dynamics, distribution costs, market share, reducing the negative effects of uncertainty of demand and increasing the product range offered (Kramarz, 2014). Omni-channel distribution is an increasingly common phenomenon. It means a combination of several distribution channels for the purposes of selling a given product category (Gołembska, 2010). It enables providing customers with more convenient access to the products offered. Many authors believe that omni-channeling is the response of enterprises with the existing distribution strategy, based on brick and mortar points of sale, to enterprises that only deal with e-commerce (Hubner, et al., 2016). Traditional channels were usually geared to distributing large volumes of products using a well-built network of distribution centers and retail stores. The most important challenge faced by these types of channels are high expectations of customers regarding last mile deliveries (Rafay et al., 2016). Omni-channeling is based on synchronized operations, where all distribution channels of an enterprise are adapted and directed towards customers, while maintaining a specific and common business plan (Bernon et al., 2016).

Spatially extended distribution channels of considerable width form network channels. In turn, overlapping network channels, whether they are related to only one or several forms of sales, form a distribution network. A distribution network is a system of cooperating distribution companies, in which relations are created at the same level of distribution channels (Kramarz, 2014). Currently, distribution networks tend to focus on the key competences of companies. Identification and knowledge of key competences is a critical point to gain competitive advantage (Deng, 2009). It is recognized, that a highly competitive enterprise concentrates strictly on its key activities, and delegates the rest of the tasks to experts in given fields (Esther, and Katuse, 2013) and combining the competences of the leader and the specialist base features of the organization can bring benefits in the form of achieving business goals (Intagliata et al., 2000). The fact that networks of cooperating enterprises should pay attention to the key and basic strengths of each network actor (Gunasekaran, and Ngai, 2003) is often emphasized. If a distribution network includes actors, who mainly specialize in the implementation of their key competences, such a network may also better respond to market demand and requirements (Elg, 2002; Gunasekaran et al., 2008). It can, therefore, be concluded, that the success of a distribution network is conditioned by the companies operating in it, including the basic functions that they perform. One can often come across a view, deemed as right by the authors, that the basic competences of enterprises are usually determined by their position in the distribution network (Thakkar et al., 2005). Considering a distribution network as one system, it can be concluded, that each element, in the form of individual links, must perform certain functions, based on key competences related to their role in the network, while other side functions do not condition the value of this link at a particular point of the network. According to the authors, the awareness of the need to identify key competences, the benefits of focusing on them and the specialization of enterprises determine activities in the distribution network that result in its reconfiguration.

One of the effects of such reconfiguration is the outsourcing of logistics services, which consists in commissioning certain logistics functions to a specialized company. These functions are usually transferred to logistics operators. The logistics operator, that provides outsourcing services, is therefore defined as the link that takes over the role of the link responsible for the rapid and efficient organization of material supplies, as well as its distribution (Grabowska, 2012). It is a logistics service provider that provides various types of logistics activities on behalf of the manufacturer or a larger retailer. The struggle of operators in the modern market takes place mainly by offering not only the lowest price, but by ensuring visibility in the supply chain, reliability and a positive approach to innovation (Cichosz, 2018). The trend in the logistics services industry is, among others, increasing the complexity of services and demand for the so-called logistics service bundles (Zelkowski et al., 2018). Enterprises in networks more and more often go beyond limiting themselves to commissioning individual activities and are looking for enterprises that provide many services. Therefore, it can be concluded, that logistics operators can improve their market competitiveness not only with regard to logistics-related services, but also thanks to a number of complementary services, which could include forecasting product demand.

In connection with the above, the purpose of this paper was to analyze material flow in the distribution network, within which the logistics operator functions. This operator is located in the Material Decoupling Point (MDP). The analysis focused on the classification of product assortment and verification of the quality of forecasts that could be made using the data available to the logistics operator. The final part of the paper is devoted to considerations on growth perspectives related to the development of operator's forecasting abilities.

2. Description of the current status quo

The logistics operator in the considered distribution network provides outsourced logistics services to a production company that makes finished products in accordance with the push strategy for distribution or logistics centers of large retail networks, as well as directly to the points of sale (POS). This operator functions as a separate link in the network. Information on the demand for products flows directly to the manufacturer from the network link, which is the next recipient of the product after the link constituted by the logistics operator. This information is a peculiar forecast related to the expected demand of subsequent links in the distribution network. In order to meet the demand and meet the requirements of its customers, the manufacturer forecasts production volumes based on historical data related to the sale of individual SKUs (Stock Keeping Units). The forecast made this way is usually based on distorted information about demand, which is distorted by subsequent links in the network and does not include activities related to its artificial creation by various links. The logistic operator gets information on the quantity of products that it has to take from the manufacturer, and then about the quantities it has to issue to individual points.

Currently, the operator is treated as a service provider, which, under concluded contracts, is required to perform tasks related to warehouse and distribution management to meet the current needs of storage and distribution. It is excluded from the flow of information on demand, even in situations where the manufacturer has obtained information about unusual quantities of SKUs that will flow through the network. At present, the operator is able to communicate without obstacles with producers through the IT system and the use of EDI between the producer and the operator. The producer sends the said information via computer network, which is processed daily by the operator and transferred to the warehouse for implementation. The operator does not currently carry out forecasting activities, and the mentioned schedules are based mainly on expert knowledge and past experience. In addition, processes are hampered by the lack of forecasts provided by the manufacturer.

The operator acts as a point of contact between streams of demand from successive DC/LC (distribution centers or logistics centers) nodes (as well as further network endpoints, to which products are delivered from these nodes) and POS, as well as streams of supply flowing from the production company. Thus, the operator acts in this network as an MDP node. Both the customer and the operator are willing to deepen cooperation and take joint action to improve the quality of customer service. The transfer of information is disrupted in the network, which, in the case of distribution to DC/LC, passes from POS to DC/LC, then to the production company, and only at the very end to the operator.

3. Material flow analysis

The analyzed quantitative data concerns a period of 2 years and was collected daily (730 observations). The product range flowing through the described distribution network covers 1,362 SKUs. This assortment was classified by the authors into 19 main product groups (Table 1).

The unit adopted as SKU maps individual commercial quantities of released products. In the next step, the levels of coefficient of variation were examined for each of 1,362 time series. In no case did the coefficient level reach a low variation level (< 20%). The results of calculations of coefficients of variation were transformed into a distribution series. The size of individual ranges associated with the values of the coefficient of variation is presented in Table 2.

Table 1.
Characteristics of product groups

Group name	Group size [SKU]	Size [%]	Share in releases (2 years) [%]	Share in releases (1 year) [%]	ABC classification		
					Number of SKUs in group A	Number of SKUs in group B	Number of SKUs in group C
Toothpastes	292	21.44%	34.10%	30.12%	79	53	160
Shower gels	223	16.37%	13.82%	12.71%	47	58	118
Special materials	242	17.77%	10.98%	17.20%	34	50	158
Other chemicals	33	2.42%	9.98%	9.05%	16	7	10
Toothbrushes	118	8.66%	9.92%	8.94%	33	38	47
Liquid soaps	57	4.19%	4.21%	4.32%	12	14	31
Christmas products	136	9.99%	3.63%	5.66%	13	31	92
Soaps	57	4.19%	3.35%	2.72%	12	11	34
Women's deodorants	42	3.08%	2.60%	2.36%	11	9	22
Mouthwashes	37	2.72%	1.55%	1.56%	6	11	20
Promotion sets	10	0.73%	1.48%	1.38%	3	1	6
Chemicals for cleaning windows	17	1.25%	0.99%	1.02%	4	3	10
Men's deodorants	21	1.54%	0.87%	0.82%	3	4	14
Others	6	0.44%	0.72%	0.53%	2	1	3
Hair shampoos and conditioners	7	0.51%	0.53%	0.35%	2	4	1
Chemicals for cleaning bathroom and kitchen	16	1.17%	0.43%	0.58%	1	4	11
Powdered chemicals	4	0.29%	0.37%	0.30%	2	1	1
Stands	41	3.01%	0.25%	0.22%	1	1	39
Tooth care accessories	3	0.22%	0.18%	0.17%	1	1	1

Table 2.
Groups divided by the value of the coefficient of variation

Groups divided by the value of the coefficient of variation	Group size [SKU]	Groups divided by the value of the coefficient of variation cont.	Group size [SKU]
Group 1	223	Group 9	46
Group 2	197	Group 10	23
Group 3	138	Group 11	38
Group 4	95	Group 12	21
Group 5	75	Group 13	11
Group 6	63	Group 14	14
Group 7	45	Group 15	196
Group 8	44	Group – none	133

The first group in terms of the coefficient of variation (Group 1) consists mostly of the product groups: toothpastes (25.56%) and shower gels (20.18%) and toothbrushes – these are also products with the largest quantitative share in the distribution network under consideration. These 3 product groups also dominate in the second and third group in terms of the coefficient of variation. The product groups that dominate quantitatively in groups in terms of the coefficient of variation with the highest ranges are Christmas products and special materials. These two groups dominate completely in groups 15, 14 and 13, and also rank high in groups 8-12. This is due to a large variability in demand for these specific product groups. Most of the product groups have the most products in the first two ranges of the coefficient of variation (Figure 1).

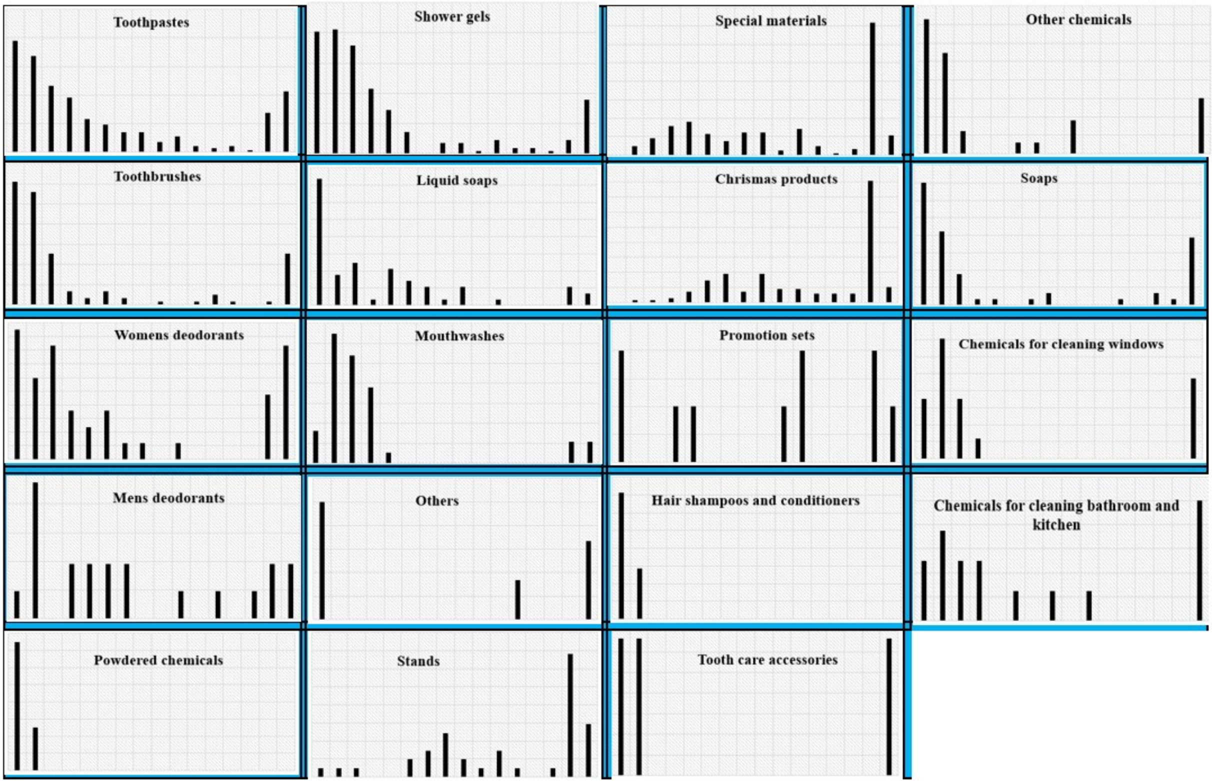

Figure 1. Distribution of product groups in individual ranges of the coefficient of variation.

According to the study, product groups with the highest percentage of products in the first range of the coefficient of variation are: toothpastes 19.52%, other chemicals 36.36%, toothbrushes 30.51%, liquid soaps 36.84%, soaps 35.09%, women's deodorants 19.05%, other 50%, hair shampoos and conditioners 71.43%, powdered chemicals 75% and tooth care accessories 33.33%. Groups that have the highest percentage of products in the second range of the coefficient of variation are: shower gels, mouthwashes, chemicals for cleaning windows and men's deodorants (20.63%, 32.43%, 35.29% and 23.89% respectively). Other product groups, i.e. special materials, Christmas products, promotional sets and stands have the highest percentage of their products in the last range of the coefficient of variation. This means that the majority of products flowing through the analyzed distribution network, apart from specific product groups related to seasonal demand or a specific form of releases, are characterized by relatively low variability.

In the next stage of the study, individual SKUs were classified according to the ABC analysis in terms of the percentage share in releases (Table 1). Group A consists of 282 products, group B – 302 products, and group C – 778 products. The largest percentage of valuable products (Group A) are toothpastes and shower gels, which can be considered the flagship products of the company served by the operator.

The analyzed product groups are delivered, as it has already been mentioned, to distribution or logistics centers (DC/LC) or directly to retail points of sale (POS). The number of network nodes to which products are transferred directly from the operator is as follows:

- DC/LC – 322 nodes,
- POS – 185 nodes.

The warehouse operated by the operator is located in Poland, while further network nodes are dispersed throughout Central Europe. In total, over 15 million products were delivered to DC/LC in the analyzed period. The product groups with the largest number of releases were toothpastes and shower gels (Figure 2).

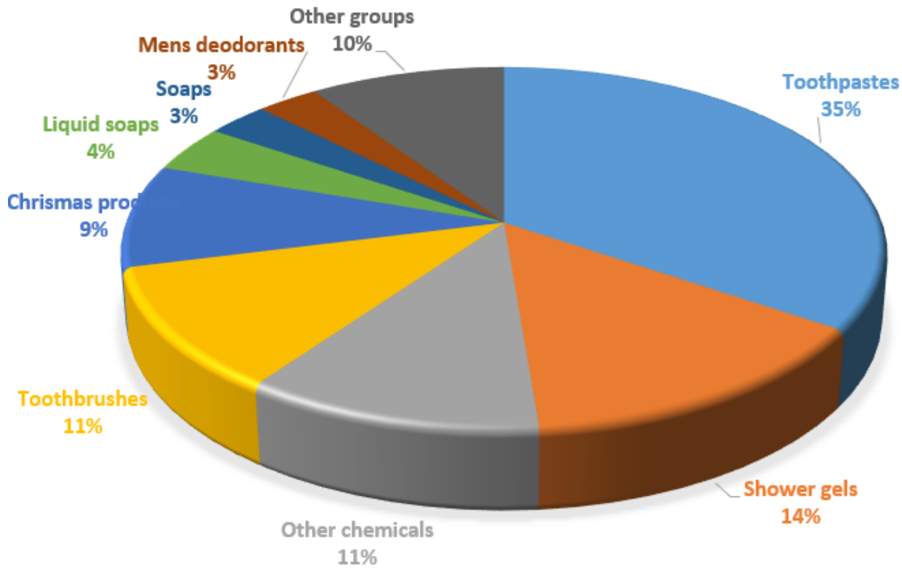

Figure 2. Share of individual product groups in releases to DC/LC.

As far as POS deliveries in the analyzed period are concerned, the operator delivered over 6.5 million products. In this case, the products from the toothpastes and Christmas products group recorded the largest number of releases (Figure 3).

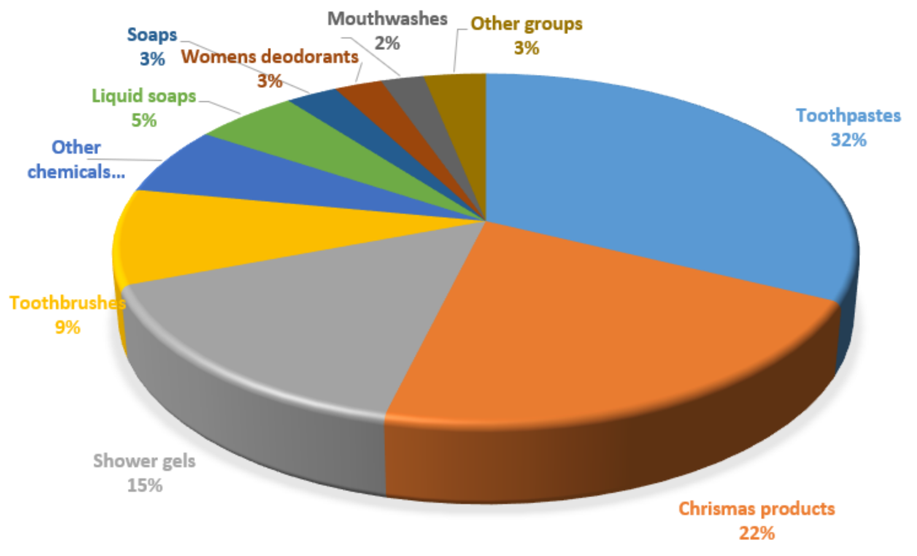

Figure 3. Share of individual product groups in releases to POS.

4. Forecasting potential

As it has already been mentioned, the logistics operator does not currently conduct forecasting activity, which significantly hinders its operations. The proposed approach focuses on an attempt to introduce forecasting based on a created tool. This tool was created in R environment and works on the basis of a written script that forecasts the demand for products for a given time horizon. The time series of individual SKUs are analyzed using 16 different forecasting algorithms, and the forecast is based on the algorithm with the smallest ex-post error in the time series test part.

The forecast for the examined distribution network was made within a 12-week horizon. After the end of this period, the forecasts were verified and, on this basis, further part of the network analysis was performed, based on product classification in terms of forecast accuracy (XYZ classification). In the adopted horizon, the projected volume of all SKUs was 5,945,796, and the real volume of releases was 6,107,885 (MAPE 2.65%) – the forecast was generally underestimated.

The XYZ classification based on forecast results grouped the SKUs into the following groups: X – SKUs with high accuracy of forecasts (282), Y – SKUs with average accuracy of forecasts (302) and Z – SKUs with low accuracy of forecasts (778). Toothpastes, special materials and shower gels had the largest share in group X. Toothpastes, toothbrushes and shower gels had the largest share in group Y.

Analysis in terms of significance of the coefficient of variation in relation to the accuracy of forecasts clearly demonstrated that the lower the coefficient of variation, the more accurate the forecast. In group X, products belonging to the variation coefficient group 1 and 2 had the largest share, the same was true for group Y (products with the coefficient of variation from groups 1, 2 and 3 had the largest share). Products belonging to groups with the highest variability had the smallest share in groups X and Y. For group X these were products from variation coefficient group 14, 13 and 15, and for group Y – products from group 14 and 13. The XYZ classification was also related to the ABC classification discussed earlier (Table 3).

Table 3.
The number of SKUs according to ABC/XYZ classification

	X	Y	Z
A	43	60	174
B	87	65	190
C	152	177	414

Products from the least desirable C/Z group constituted the largest share. This may mean the need to re-analyze the entire product range for possible discontinuation of production and distribution of such products. The ABC/XYZ classification was also related to previously identified product groups (Figure 4).

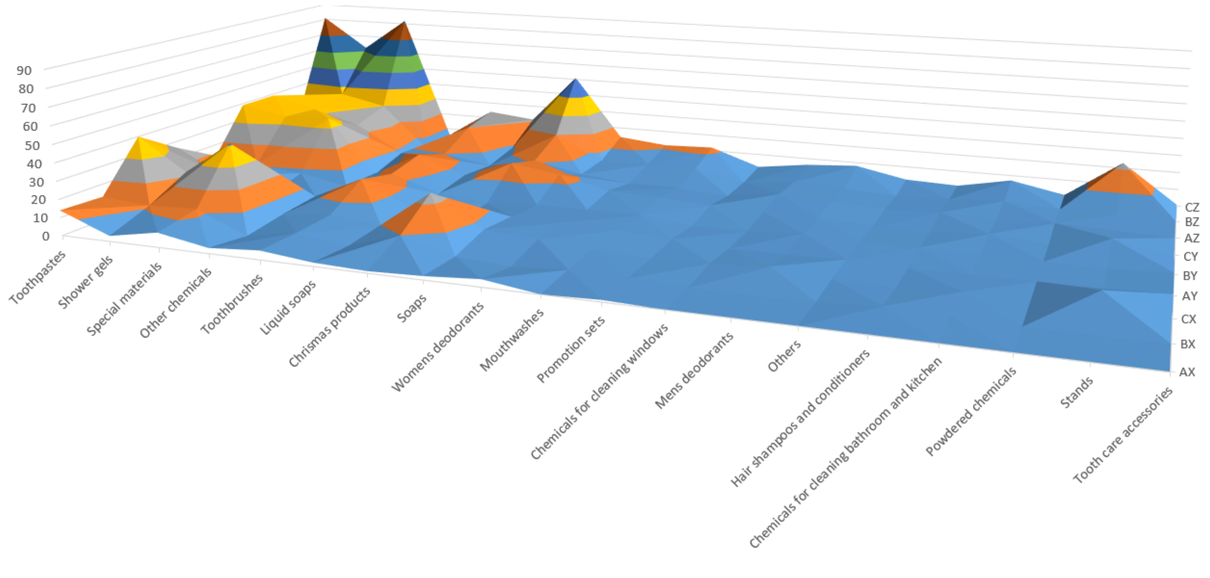

Figure 4. The number of SKUs from individual product groups according to ABC/XYZ classification.

Toothpastes account for over 32% of the A/X group. Also taking into account earlier considerations, it can be concluded that this is the product group on which the company should put the greatest emphasis in terms of operations performed on it. Other product groups that significantly contribute to the A/X group are toothbrushes, shower gels and other chemicals. These groups also appeared in earlier analyzes and this means that the company should also treat them with priority. The C/Z group included Christmas products and special materials. However, the company cannot afford to eliminate them, because they are products that are either released seasonally or are a leverage for the sale of other, more valuable products.

6. Summary

The paper has shown the potential of material flow analysis in a distribution network from the perspective of a logistics operator operating at MDP point. This analysis allowed to group and characterize the flowing products in terms of respective sales groups and in terms of the value of the coefficient of variation, which characterized the variability of release levels over time. In addition, ABC analysis was also carried out, which grouped the products in terms of their release volume. The approach presented in the paper also considered the possibility for the operator to undertake network forecasting activities. In this respect, a tool was created, that enabled forecasts to be made within a given time horizon. The results of the forecasts enabled further analysis of material flow, taking into account the XYZ classification. Classification results have been compared with previously obtained ABC classification results, as well as with the value of the coefficient of variation and the product groups themselves.

Analysis showed which product groups the company should prioritize and which groups constitute a relatively simple task related to forecasting the volume of their releases. However, in order to obtain a better forecasting effect, reconfiguration of the distribution network should be carried out, which should mainly focus on including the operator in forecasting activities, facilitating the relational aspect of the network and improving the flow of information within the network. This is an interesting area for further research.

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