The Strategy of Bullwhip Effect Minimization in Livestock Feed Supply Chain

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Abstract: The studies in the literature that have analysed distorted information in supply chains reported the presence of the Forrester effect, or the bullwhip effect. In the systems theory, this phenomenon is termed the butterfly effect. Regardless of its name, the effect causes that small disturbance in initial conditions causes significant disturbances in operation of the whole system through system amplification and feedback. In the logistics chain, this effect manifests itself in the transfer of the amplified changes in the demand towards the initial part of the chain. This mechanism results from a marketing approach to the customer's need and the highest possible level of customer service and striving for rational business activities in the enterprises in individual cells of the logistics chain. Readiness of individual links in the chain for meeting the expectations of the recipients causes that each entity attempts to collect the amount of product equal to individual sales plus a specific reserve in case of unexpected fluctuations in supply.

Keywords: enterprise strategy, management of supply chain, logistics management.

1 Bullwhip effect minimization

The universal activities postulated during limitation of the bullwhip effect include in particular [9]:

Sharing information. First and foremost, one should ensure exchange of high-quality information between all the entities throughout the supply chain. Enterprises need to have access to the data which improve the effectiveness of supply chain management and are necessary to limit the Forrester effect. It is necessary to equip any enterprise in the data about the original demand from retail sales points that ensure input data for demand forecasting and planning business

operations. From this standpoint, essential information for management of material flow through the chain includes: information about promotional campaigns, amounts and availability of supply at individual levels of the chain and also the access to internal data concerning production plans or opportunities to track order fulfilment. Current and updated data from each link in the supply chain help minimize level of supply and costs since it prevents ordering goods in advance. A necessary element of the effective information exchange is implementation of a uniform information technology in all the entities throughout the chain as well as on-line access to the system data.

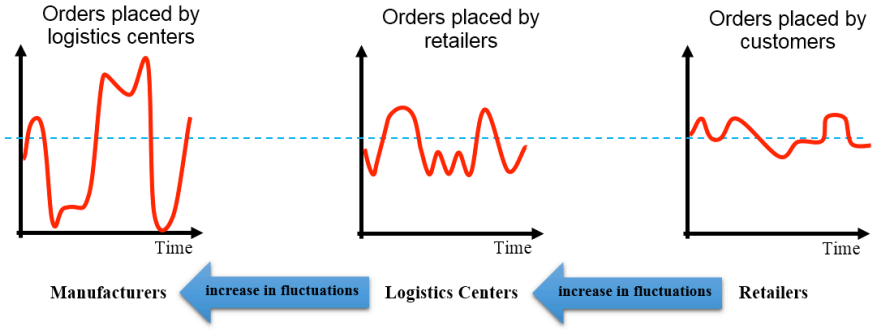

Figure 1
Forrester effect in supply chain
Source: author's own elaboration based on [4]

Coordination of processes in the supply chain and making decisions together. Members in the chain should use the information for synchronization of demand forecasting and planning production in order to fully utilize production potential and, consequently, coordinate supply, order fulfilment and inventory levels throughout the supply chain. With standardization of the principles for order placement and stock replenishment, the enterprises implement continuous replenishment processes (CRP). Furthermore, implementation of information technologies in the chain to allow for using this system shortens the time and reduces the costs of sending orders. Therefore, it promotes the systems based on frequent order placement instead of grouping the orders. One element that reinforces the system presented in implementation of the strategy of uniform and low prices. Enterprises share both benefits and risks that result from integration of activities.

Shortening the lead time. Facilitated material and information flow through the supply chain helps shorten the lead time and, consequently, improves the ability of the enterprise to quickly and flexibly respond to the changes in the demand and customer needs. The previous systems of maintaining high inventory levels, which used to protect against high demand variations, are being replaced by the pull systems. This system ensures that the demand for products from customers drives

material flows. Quick response in the supply chain improves the quality of customer service and reduces inventory levels. Efficient exchange of information and elimination of uncertainty of changes in the demand might lead to two- or three-percent increase in the level of services with reduction in supply level even by 25 percent and improving the efficiency throughout the supply chain [3], [5], [8]

Nowadays, customers in Poland require much more from logistics service providers. They expect not only distribution or warehousing but management of the whole supply chain and processing the deliveries in their own warehouses. In the Western Europe, logistics providers are increasingly taking over the roles of a consultants, process and cost optimisers, which is also being observed in Poland. However, it is becoming necessary to focus on developing logistics services and after-sales services. Surveys show that this is undoubtedly the biggest weakness in Polish logistics market. There is also another deficiency of something which is becoming a standard in the Western countries: participation of logistics service providers in the information flow, i.e. B2B between logistics providers and customers.

2 Perspectives in the logistics services market in the light of "Europa 2020" strategy.

According to the assumptions of the Europa 2020 strategy, which represents the continuation of the Lisbon Strategy, it is necessary for the member states to cooperate in order to overcome crises and implement reforms that help face the challenges of globalization, society ageing and the growing need for rational utilization of resources. In order to achieve the above assumptions, three basic priorities have been proposed [1],[12]:

- smart growth, i.e. growth based on knowledge and innovation,
- sustainable growth, i.e. transformation towards a more resource efficient, greener and more competitive economy,
- inclusive growth, i.e. fostering a high-employment economy which is characterized by high economic, social and territorial cohesion.

Therefore, it can be observed that Europe is striving for sustainable development. This also concerns logistics. Integrated EU policies in the field of logistics and transportation represent a response to the European economy entering the stage of continuous growth. However, it is unsure whether the role of the transportation and logistics sector was properly taken into consideration in these policies.

Value of the logistics sector in Europe is primarily manifested in that it generates billions euro of revenues and millions of workplaces. However, these numbers do

not reflect the real strength of the sector, with its essence being a combination of the relationships between services and costs that improves value creation and effectiveness of logistics it generates for European exporters and consumers. Each administrative obstacle and each queue on the border generate costs and reduce competitiveness of European products abroad and increase in prices of important goods. The regulators used for ordering the market must take into consideration, apart from the interests of customers, the interests of speditors and consumers, which causes the necessity of remodelling the logistic market in Europe. Legal standards in terms of market regulation should integrate the postulates concerning the increase in cabotage transport and the necessity of using new standards of safety [2], [13].

Logistics service providers represent an essential element of the economy. They support macroeconomic processes, ensure the infrastructure necessary for distribution of goods to enterprises and consumers. Their activities also affect the environment since 14% of overall carbon dioxide emission generated by humans originate from transport, of which a third concerns transportation of goods. Therefore, logistics service providers must take responsibility and start investing in more ecological solutions that offer opportunities for reducing environmental degradation. One example of the logistics service provider that implements this strategy is Deutsche Post DHL, which declared improvement in efficiency and reduction in carbon dioxide emissions by 30 percent by 2020. The objectives will be achieved through optimization of the supply chain, changes in the supply mode, optimization of the network and the use of more efficient technologies [3], [14]. However, responsibility for green and efficient logistics is on EU politicians and regulatory authorities. It is necessary to implement the multi-directional approach which will promote involvement of the logistics sector in sustainable development and growth in Europe.

Real and uniform market of transport and logistics services is a key in development of the European Economy, which was recently confirmed by the European Commission. In the nearest time, it should enforce liberalization and free competition for all means of transport and reduce administrative barriers, especially in the sectors of transport where regulations are excessive. Limitation of cabotage means more empty runs, whereas the interests of national forwarders might negatively affect development of effective rail connections, for instance from the Iberian Peninsula to Scandinavia. Local interests also cause delays in implementation of the Single European Sky thus delaying substantial reduction in fuel consumption [15]. Restraint from additional regulations is possible as long as transport markets are protected and do not negatively affect implementation of the respective EU regulations. New regulations must be effective and non-discriminatory, contrary to the present Eurovignette system which assumes penalties for dishonest practices, but it does not encourage supply system improvement. A number of logistics solutions implemented in the area of vehicle transport is much more ecological than solutions implemented in the railway

system (depending on the cargo and the route) and might represent the basis for best practices in the area of logistics. They represent the stimulus for promotion of smart and sustainable logistics solutions. Furthermore, regulation and preventing from the increase in costs will motivate enterprises to search for more ecological solutions in terms of the supply chain. The European Union must combine the effects of a full and uniform market with encouragement to use modern and green solutions. Comprehensive solutions for the whole sector are connected with the integrated approach that involves better coordination of activities and projects that represent the outcome of consultation dialogues of decision-makers in logistics sector, suppliers and carriers.

In order for the assumptions of the Europe 2020 to be met it is necessary to create a uniform market and plan to implement ecological solutions in the field of logistics and improve efficiency of the supply chain.

3 Research methodology

Considering application of RFID technology in the process of management of the supply chain and with respect to the assumption which says that the system allows for limitation of the Forrester effect (or the bullwhip effect) in the supply chain, the livestock feed supply chain was investigated with regard for current status where information flow between the links in the chain occurs to the insignificant degree. Application of the RFID system would allow for obtaining real-time information, thus eliminating excessive increase in supply among suppliers, manufacturers and recipients of livestock feed. It is particularly significant in the sector discussed due to its specific nature, since substantial variations cause particular difficulties in proper prognosis of the demand and generate excessive supply throughout the supply chain.

The research methodology was based on the solutions proposed by F. Chen[1] and R. Bhatnagar, Ch. Teo[2]. The following equations were used:

[1] F. Chen, Drezner Z., Ryan J.K., Simchi-Levi D., *Quantifying the bullwhip effect in a simple supply chain: the impact of forecasting, lead time, and information*. Management Science 46/2000 (3), in: Bottani E., Montanari R., Volpi, A., *The impact of RFID and EPC network on the bullwhip effect in the Italian FMCG supply chain,* Int. J. Production Economics 124/2010, p. 429

[2] R. Bhatnagar, Teo Ch., *Role of Logistics in Enhancing Competitive Advantage: A value chain framework for global supply chains*, International Journal of Physical Distribution & Logistics Management, Vol. 39/2009 Iss: 3, s.212; and M. Nowicka-Skowron, *Logistyka globalna a kreowanie przewagi konkurencyjnej przedsiębiorstw*, [in:] co-authored study, *Logistyka w naukach o zarządzaniu*, Wyd. AE Katowice 2010, p. 121

$$\%\ \text{reduction in the Forrester effect} = \frac{\sqrt{\frac{var(q^n)}{var(D)}}|_D - \sqrt{\frac{var(q^n)}{var(D)}}|_C}{\sqrt{\frac{var(q^n)}{var(D)}}|_D} \quad (1)$$

$$\%\ \text{reduction in the Forrester effect} = \frac{\sqrt{var(q^n)}|_D - \sqrt{var(q^n)}|_C}{\sqrt{var(q^n)}|_D} = \frac{\sigma(q^n)|_D - \sigma(q^n)|_C}{\sigma(q^n)|_D} \quad (2)$$

$$\frac{var(q^n)}{var(D)} \geq 1 + \left(\frac{2\left(\sum_{i=1}^{k} L_1\right)}{p} + \frac{2\left(\sum_{i=1}^{k} L_1\right)}{p^2}\right) \quad (3)$$

where:
L - cycle of supply replenishment,
$var(q_k)/var(q^n)$ - variance of orders determined by k level of the supply chain;
var (D) - variance of the demand of the final customer;
k - supply chain level,
p - the constant that determines the most current observations of the supply.

Reduction in the Forester effect is expressed as an economic effect on reduction in the safety stock using the following equations:

$$SS^n = k\sigma(q^n) \quad (4)$$

$$\%\text{reduction in safety stocks} = \frac{SS_D^n - SS_C^n}{SS_D^n} = \frac{k\sigma(q^n)|_D - k\sigma(q^n)|_C}{k\sigma(q^n)|_C} = \text{reduction in the Forrester effect} \quad (5)$$

$$\text{reduction in safety stocks} = SS_D^n - SS_C^n = SS_D^n \times \%\ \text{reduction in the Forrester effect} \quad (6)$$

$$\text{economic effect} = \text{reduction in safety stocks} \times \text{cost of stocks maintaining} \quad (7)$$

Using the above assumptions in the supply chain discussed, the investigations were based on the data collected from four suppliers and information from a manufacturing plant. The chain is composed of the three levels: manufacturing plant, distribution centre and customers. Quantitative parameters used for analysis are averaged in the case of the number of pallets flowing in the assumed cycle of stock replenishment, inventory level and mean level of used for demand forecasting. From the standpoint of the sector analysed in this study, ensuring real-time access to the data about the demand in real time is particularly essential in minimization of the bullwhip effect. Livestock feed industry is characterized by

substantial seasonal variations and the entities are independent in their decision-making in terms of implementation of the policies of inventory management and willingness of managers to overestimate the demand as a result of obvious imperfectness of prognoses and fast changes in the market that prevent ensuring flexibility in reacting to the demand that originates from customers. Minimization of the Forrester effect requires close cooperation of supply chain links and common policy for collecting stock, which causes the necessity to ensure reliable and quick exchange of information.

Two scenarios were used in the supply chain analysed: the lack of information flow between partners in the supply chain and collecting information in the centralized form. Tagging was assumed at the level of pallets.

Parameters that characterize the supply chain	Value in the manufacturing plant	Value in the distribution centre
Expected time of stock replenishment *L* [in days]	12	6
time interval *t* [in days]	8	8
Safety stock [in pallets]	5000	4000
p=0: reduction in the Forrester effect - decentralized scenario - centralized scenario - % deviation of the Forrester effect - economic effect [PLN/year]	 12% 24% 30% 644137	 2% 1.5% - -
p→±1:reduction in the Forrester effect - decentralized scenario - centralized scenario - % deviation of the Forrester effect - economic effect [PLN/year]	12% 0.8% 72% 1832971	2% 0.8% 37% 921732

Table 1
Results of the examination of the Forrester effect in the supply chain
Source: author's own elaboration

The results obtained at p=0 and p →±1 assume upper and lower threshold of the RFID effect on the Forrester effect. The numerical data show that, with the lack of correlation between the demand (p=0) using RFID might involve considerable reduction in the effect for the manufacturer. In particular, standard deviation of the demand decreases by 30.1% for pallet tagging. With the decline in the standard deviation of the demand, the effect is becoming less noticeable by the distribution centres. At the stage of pallet tagging, it is impossible to improve transparency of information for distributors since they have the access to the data concerning sales and therefore the bullwhip effect is not reduced.

Conclusions

Supply chain management represents the subject of a number of scientific studies. Analysis of the research problem of bullwhip effect in supply chain was aimed at showing the relationships between application of suitable RFID technology and collecting the stock. The paper presents the methods of minimization of bullwhip effect in the logistic chain and discusses the problems of the market of logistics services in the perspective of the European development strategy. Two scenarios developed in the study. They assumed varied approach to storing information about the supply. The results obtained demonstrate that, in specific cases, the relationship occurs between information flow and the Forrester effect, which allows for taking actions in order to reduce this effect.

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