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ANALYSIS OF THE FORRESTER EFFECT (BULLWHIP EFFECT) IN THE DISTRIBUTION NETWORK - CONCLUSIONS FROM THE "BEER GAME" SIMULATION

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ABSTRACT. We are currently witnessing an increase in various forms of cooperation between companies, both in terms of partner integration level and intensity of their contacts. However, although we are living in the age of local and global supply chains, we still stick to a range of old habits (business process atavisms). The bullwhip effect (the Forrester effect) constantly takes place in everyday business life, manifesting itself more or less powerfully. It seems paradoxical (a self-fulfilling prophecy) that although the mechanism of the phenomenon appears to be known, practice proves that partners' particular interests (local wins) have a strong impact on decision-making. This seems to be nothing unusual given the contemporary market conditions and the ruthless competitive battle taking place. However, what is beneficial to one of the supply chain participants may be just lethal to the supply chain as a whole (lack of team wins). The theory on the one hand, the practice on the other - own studies of the phenomenon conducted among amateurs and experts in the area constitute a contribution to conclusions from the analysis. Insights are presented from the viewpoint of the psychology of human action (the need to make decisions) which is so strongly imprinted into human nature. The study is based on research into material streams optimization in the logistics of distribution conducted by the authors within the framework of a research project in the Department of Logistic Systems.

Key words: physical distribution, supply network (chain), bullwhip effect (whiplash effect), Forrester effect, beer game (beer distribution game), simulation.

INTRODUCTION

One of the most popular issues in the area of physical distribution is the Forrester effect (the bullwhip effect). Although discovered half a century ago, the phenomenon remains interesting to both logistics practitioners and theoreticians, which is confirmed by the volume of research and theoretical studies devoted to this subject. Currently, revived interest in the bullwhip effect can undoubtedly be attributed to the popularity and development of one of logistics strategies - supply chain management.

The desire to understand the causes and mechanism of the Forrester effect has led to developing a simulation known as the beer game (beer distribution game). The simulation method makes it possible (in a virtual reality) to see interrelationships between decisions taken and results obtained - fast, costless and risk-free.

This paper aims at drawing practitioners' attention to some basic aspects connected with the order generation and delivery execution which are observed in supply chains operation, depending on the behavior strategy adopted by a given participant of the supply chain.

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THE GENESIS AND NATURE OF THE FORRESTER EFFECT

The regularity which is under discussion here was first observed by Jay Forrester back in 1958. Consequently, the phenomenon is often referred to as the Forrester effect [Rutkowski K., 2005, Senge P.M., 2006]; currently in delivery chains we also come across another term to refer to it - the bullwhip effect (whiplash effect, whipsaw effect) [Bobowska J., 2002, Pluta-Zaremba A., 2009, http://elettery.pl/archiwum/eletter.php?id=6993]. Jay Forrester, who was dealing with the issue of systems dynamics, noticed that even slight changes in demand deviations occurring at the bottom of the logistic chain increase steadily as they go upstream. His research resulted in a theory that specified the principles of transferring the demand amplification. Transferring the demand changes resembles the acting principle of a whip as described in the language of physics (hence the name).

In general, the Forrester effect is connected with attributing the feature of permanence (invariability) to trends observed in the marketplace. Company managers tend to act in accordance with the (erroneous, though not thoroughly) mechanism: if a given phenomenon is currently on the upward trend, we think that it will continue going up in the future (similarly in the opposite situation: if something is currently on the downward trend, we think it will keep going down). When we set out to analyze the market demand, it will be very easy to account for the differences between our predictions (anticipating the future) and the reality (actual sales). We end up with the error of assuming trend continuation - overestimation of demand (excessive stock) or underestimation of demand (costs of lost sales). Another factor contributing to the Forrester effect is the time and place gap - the time and space of the demand (the marketplace) is different from the time and place of covering the demand (the manufacturer). Since the time it was first described, the bullwhip effect has been observed in numerous businesses operating in various branches.

The general idea of the Forrester effect is that demand variations are increasingly amplified as one moves upstream in the supply chain (from retailer through wholesaler up to the manufacturer). Information passed on to another element of the supply chain is distorted, because apart from the actual demand variation they incorporate decisions concerning the given supply chain participant's stock policy, as each of the supply chain participants tries to secure some safety stock in case of unexpected demand variations.

CAUSES OF FORRESTER EFFECT - TRIGGERING FACTORS

Major reasons why the Forrester effect is observed in practice include:

- lack of information flow between business partners (lack of communication, lack of conversation);
- concentrating on the results of market phenomena (e.g. an increase in order volume which is usually positively received), without trying to investigate actual reasons for this state of affairs (lack of market analyses to answer the question what happened and why it happened, and concentrating on the operating activities disregarding any conceptual work);
- simplified methods of management (most often the stock level planning takes the form of the equation: demand = supply).

In consequence, the demand variations moving upwards the supply chain become more and more amplified, which ultimately leads to excessive increase in stocks in the whole supply chain and the resulting bullwhip effect.

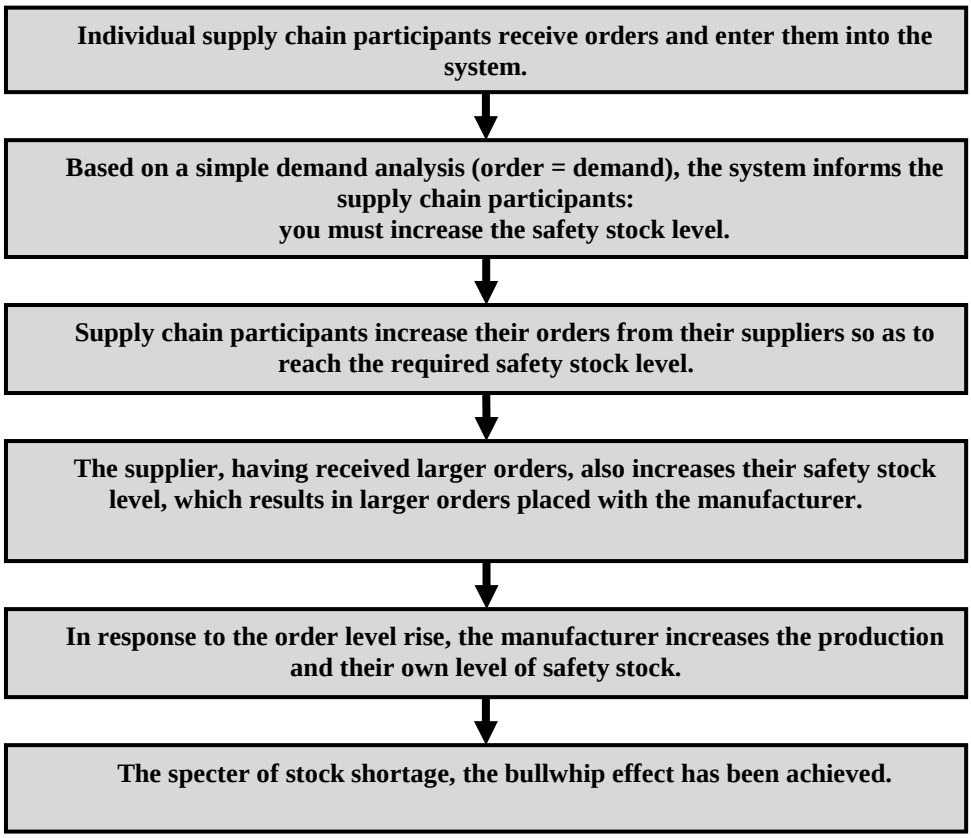
The key factors responsible for the Forrester effect include:

- demand fluctuations on the retail market (market fluctuations move along supply chains resulting in the problems escalation in the successive supply chain elements - the downward spiral effect);

- price changes, in particular those previously communicated (increase/decrease in prices results in hardly foreseeable actions connected with building up/getting rid of stock - the purchasing and delivery policy is hard to predict);
- rationing of deliveries (limiting the supply possibilities usually results in an increased tendency to make even unreasonably large purchases);
- shortage of products (as a result of problems with obtaining some product categories, the moment the products are available they are purchased immediately - just for the sake of getting hold of them, while cost issues are disregarded);
- large unit loads (enlarging the size of logistic packaging translates into the volume of placed orders, which results in sporadic orders, but for very large quantities);
- unstable stock policy (lack of rational stock management - segmentation, purchase budget, methods of optimization - is accompanied by casual moves in the area of the purchasing operations);
- a long supply chain involving numerous participants (number of cooperating entities and their location has an impact on the occurrence and scale of the phenomenon in question - due to the system's inertia).

Demand fluctuations in the retail market often resemble the butterfly effect, where insignificant variations downstream the logistic channel cause some kind of storms upstream.

MODEL OF FORRESTER EFFECT ORIGINATION



Source: own study based on [http://elettery.pl/archiwum/eletter.php?id=6993, March 2009]

Fig. 1. Algorithm of Forrester effect generation
Rys. 1. Algorytm generowania efektu Forrestera

The diagram of the bullwhip effect origination in a distribution network resembles playing the game of Chinese whispers. The basic factor responsible for the occurrence of the phenomenon is ineffective flow (exchange) of information between the cooperating parties.

THE BULLWHIP (WHIPLASH) EFFECTS

The consequence of the algorithm of Forrester effect generation in a distribution network is an increase in the safety stock level in the individual links that make up the supply chain. As a result, larger and larger orders are now placed. Each of the supply chain participants, looking upward the value chain up to the producer, has problems with meeting the increased orders. This leads to a further increase in orders level and in consequence a rise in the safety stock level, which creates a dangerous upward spiral of demand amplification.

Such behavior is a consequence of concentration on the result - taking an assumption that the increase in the orders level directly reflects the market demand, without analyzing the underlying causes of that phenomenon, while the truth might be different. The stock increase may be related to the simulated reactions of demand variations in individual links of the supply chain when:

- they do not have up-to-date information about the market,
- they have problems with interpretation of the information about the demand,
- they concentrate on their own (partial), and not the ultimate demand (supply chain).

On the consumer market, where it is the consumer that dictates the conditions of cooperation, businesses strive to ensure an extremely high level of customer service. Each participant of the value chain accumulates stocks in amounts calculated as the received order quantity increased by a certain reserve. In fact, the surplus is far bigger than it is required due to demand variation (standard deviation of demand). If the information exchange takes place step by step, the longer the chain, the more intensive the phenomenon will become as it goes up the chain. The orders and stock levels at the manufacturer's (demand accumulation) will be inadequately high in relation to the current market situation development - the customer behavior in retail outlets.

COUNTERACTING THE FORRESTER EFFECT

The practice of stock management in supply networks contributed to the identification of various aspects that may be applied to help limit the bullwhip effect. The all-important issue is a very efficient flow of reliable information between supply chain participants. It is information that precedes, accompanies and ends material stream flows; therefore, it is very important for marketing and sales departments to cooperate effectively with the other organizational units. Also, the supply chain architecture should be submitted to analysis with the ultimate goal to constrict the supply chain down to its indispensable participants (shortening the supply chain).

Shaping the sales volume requires a good knowledge, analysis and specification of such phenomena as seasonality and trends. Monitoring the market on a current basis, both at the general level and with regard to a specific market segment, helps identify and control behaviors of market players. Each market phenomenon should be duly analysed. It is reprehensible to adjust to a new situation in a passive and unquestioning way, without considering any possibilities of influencing it proactively. There are a number of tools developed at the stock management operation level. One of the approaches - stock centralization in the supply chain - seems to be a remedy for the bullwhip effect.

The distribution policy applied (price changes, special offers) also has an impact on the delivery network operation. Before raising prices, an increase in orders can be expected, while shortly after a price rise, the demand will temporarily fall down. Promotional activities during a product launch are

characterized by the push technique - building up stocks, whereas during promotional actions and towards their ends the pull technique prevails - the stock level is adjusted to market needs.

Stock and transport are the two main pillars of logistics. Transport is the intermediary between the customer supply logistics and the seller distribution logistics (stocks of materials and raw materials and finished products). The delivery cycle (more precisely, the frequency of transport cycles) to a large extent determines the lack of susceptibility of the supply chain to the Forrester effect.

THEORETICAL CONCLUSION

The conclusions drawn from the study of the Forrester effect should be considered within a systemic and a personal framework. The final result is usually the state in which a chain is haunted with a prospect of bankruptcy (result of the simulation game).

Regardless of the doings and knowledge of decision-makers, the system organization itself generates distortions. In this situation, a crisis - in the form of stocks shortages or excessive stocks resulting from lack of orders or excessive orders, which in turn is a consequence of the trend gap and the time and place gap - is only a matter of time.

One of the factors that counteract the bullwhip effect is a proactive approach taken by managers. A supply chain is a system which, as any other system, is characterized by some level of resistance and susceptibility to distortions. It is decisions taken by particular supply chain participants (managers) that generate the bullwhip effect. It is very easy to evoke it, but it could be much more difficult to regain the homeostatic effect in the future.

Human decisions are certainly made rationally. However, rationality is referred only to a fragment of the supply chain. In many cases, decisions that are optimal for a given supply chain participant are not optimal for the system as a whole (the supply chain), although we cannot rule out situations where the opposite is true.

The knowledge of the system's architecture and its functioning system is the starting point for introducing changes aimed at counteracting the phenomenon (management models and operation techniques).

THE BEER GAME METHODOLOGY - ASSUMPTIONS, GOALS, RULES, IMPLEMENTATION PROCEDURE

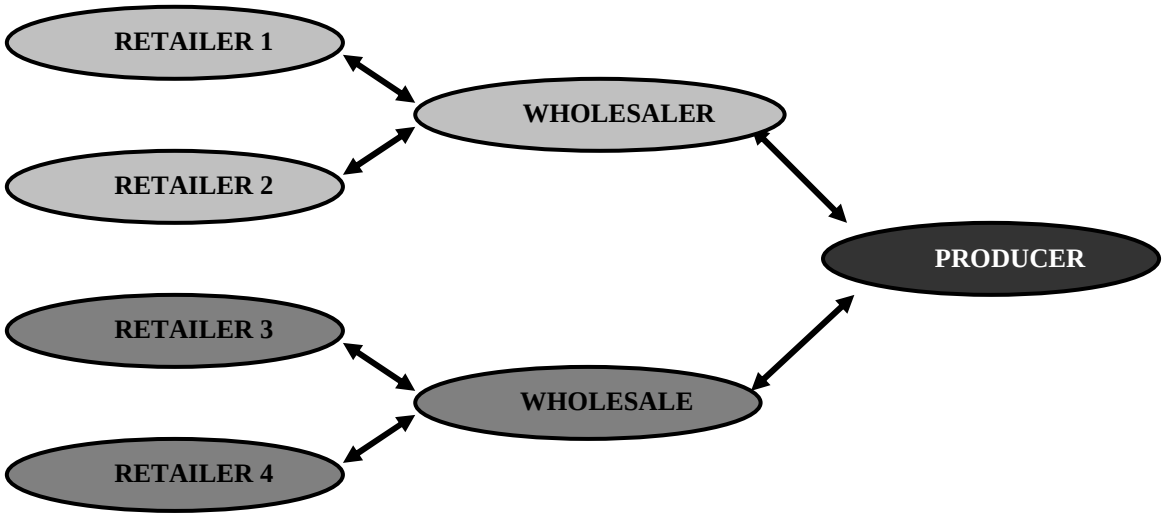
The Beer Game is a simulation game which makes it possible to hone managerial skills in interaction with other participants [http://www.door.com.pl/manual_beer.pdf]. A participant may take on one of the following roles:

- the retailer who places orders with the wholesaler,
- the wholesaler who places orders directly with the manufacturer,
- the manager of the brewery (the brewery warehouse).

In the simulation game, the supply network architecture consists of: 4 retailers, 2 wholesalers and 1 manufacturer. There are strict assignment rules in place: retailers No. 1 and 2 place orders only with wholesaler No. 1, whereas retailers No. 3 and 4 place orders exclusively with wholesaler No. 2; both wholesalers place order with the manufacturer. The delivery lead time (delivery cycle) between the retailer and the wholesaler is twice as short as the delivery lead time between the wholesaler and the manufacturer (delivery lead time is twice as long upstream).

Each player's task is to analyze data, develop an operations strategy and make concrete decisions (placing orders and receiving deliveries). The game's goal is to make a maximum profit (the

difference between the profits and the stocks value). This is to be achieved by means of attempting to optimize volumes of placed orders and their execution.



Source: own study

Fig. 2. Architecture of a supply chain - beer game participants
Rys. 2. Architektura łańcucha dostaw - uczestnicy gry piwnej

The simulation game is played in several dozen rounds. Each round corresponds to one week of the business operation. During each of the rounds, based on the current market condition - information obtained from contracting parties (cooperating participants of the supply chain) and the game facilitators (data on the customers' demand volume) - each player makes decisions which will affect the condition of business in the periods to come. The specific rules of the beer game will not be quoted here, as they are very detailed, which may divert the focus from the issue at hand, and it is not necessary to know them in order to understand the conclusions drawn from the simulation. The beer game is a simulation experiment which may be conducted in various forms. In this case, the paper form was chosen, as it ensures better understanding of the particular elements of the supply chain and of the information and material streams flow (a better understanding of the game process and the resulting interrelationships).

The Forrester effect simulation is carried out in the form of a workshop class which usually consists of 3 stages (so as not to spoil the fun of the game, first the participants cope with the game problem, and then they set about analyzing it in theoretical terms:

- preliminary presentation of the subject - specification of the game's participants, its goal and its rules;
- simulation game ended with presentation and discussion of the results;
- final thought - theoretical background of the beer game (the theoretical part of this article).

The participants starting the game know where the problem lies and they try to prevent it. The main part of the workshop class is the simulation game. On finishing the game, its results are gathered and presented in the form of graphs which are the basis for discussing the game. In the course of exchanging their thoughts, very often the participants single-handedly discover regularities involved in the bullwhip effect. The third part of the workshop is devoted to the theoretical grasp of the achieved empirical experience. The participants gain a thorough knowledge of the beer game problem. The final stage is aimed at structuring the knowledge of the Forrester effect.

BEER DISTRIBUTION GAME - RESULTS OF THE EXPERIMENTS

The research experiment included two simulations of the beer game. The participants of the first simulation were professionals - both theoreticians and practitioners (persons whose professions were connected with the problem in question), whereas the participants of the other simulation were amateurs - laymen in this field (beginners only starting to gain experience in the area of logistics). Two situations were varied empirically: in simulation No. 1 the delivery cycle from wholesale to retailer was 2 weeks, and the delivery cycle from producer to wholesaler was 4 weeks; in simulation No. 2 the delivery cycles were in both cases halved (to 1 and 2 weeks, respectively). In both situations, all the four retailers had the same distribution of demand and the same total volumes of demand (retail demand profiles described as: a surge, a slump, a slight increase, leveling off, a surge). However, in the case of each of the retailers the demand for a given week was slightly different (similar) with a view to reflecting the market competition reality. The game analysis was conducted on the basis of information gained from 4 fact sheets: covered demand, status of orders, closing stock level, final balance of the simulation. For the purposes of this article, we shall concentrate mainly on interpreting the status of orders and the stock level (purchasing and delivery policy in a network).

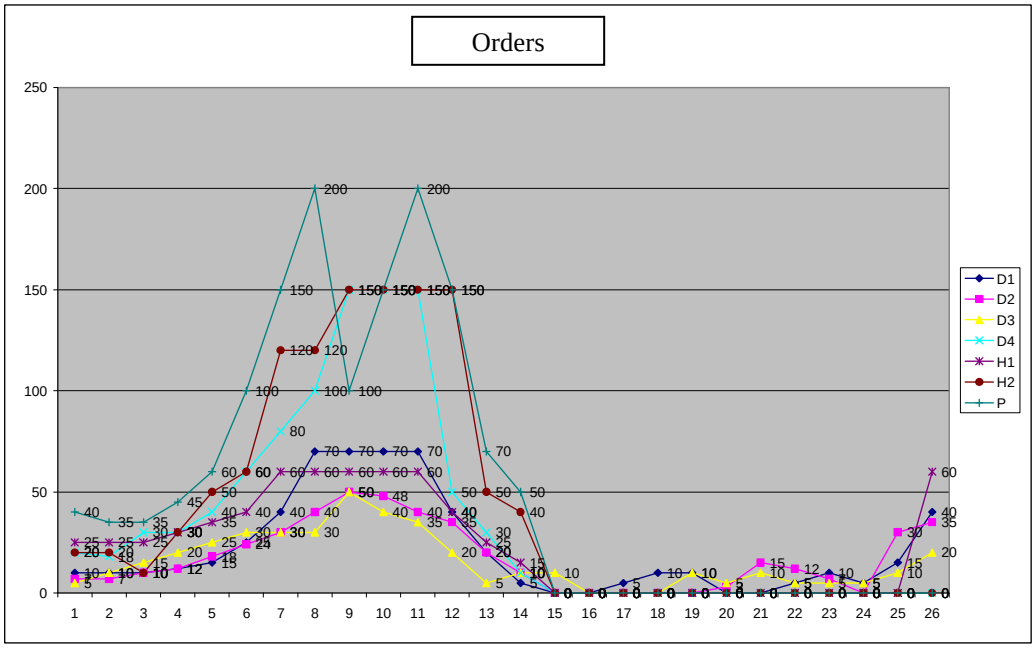
SIMULATION 1 - PROFESSIONALS

As for covering the demand, the unquestionable leader among the retailers was outlet No. 4 - it was the result of building up stocks. As for both wholesalers, they obtained comparable results (wholesaler No. 2 did not take advantage of retailer No. 4 achievements).

Slight fluctuations in demand at the retail level generated significant turbulences up the value chain (the butterfly effect). The vertical analysis of the orders graph shows clearly that increased purchases made by particular supply chain participants promoted the willingness to increase the stock level, which in turn led to a further increase in the orders - the irrational escalation of the problem. This tendency results from the lack of knowledge of the ensuing situation and the lack of communication and information flow between the supply chain participants. Each participant of the supply chain attempts to secure their own interests (readiness to sell products). Therefore, apart from the rational volume of goods determined by the demand they order larger amounts to build up reserves and thus secure their future.

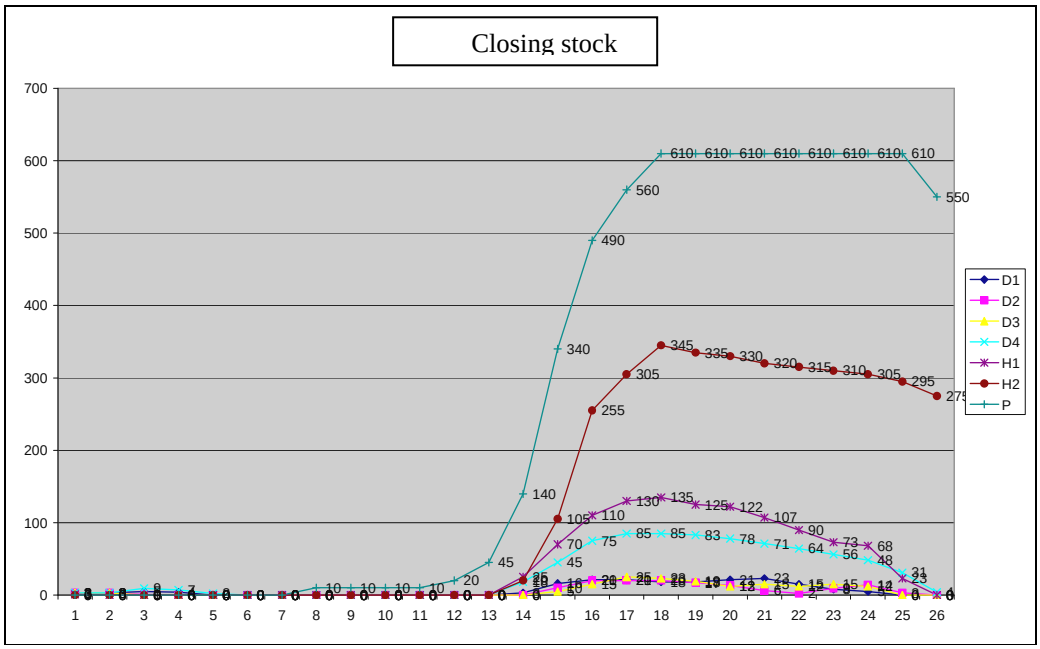
As for stocks, we observed characteristic moments of the beer game: the moment of clearing the distribution network from any accumulated stocks (beginning of the simulation), and the moment the distribution network was suddenly filled up with an excessive stream of goods. The final stocks levels depended on the demand profile. The retailers faced another wave of demand, which allowed them to sell off the stocks. However, in the case of the wholesalers and the producer's warehouse, any decrease in the stocks levels was only possible when the retailers resumed placing significant orders with the wholesalers.

For most of the participants, Simulation No. 1 ended with losses, the others managed to balance their operations (small, marginal rate of return). The good results obtained by the retailers were attributed to demand revival. It was perfectly clear that the turbulences going up the supply chain were becoming more and more intensive. The actions of retailer No. 4 generated problems on a much larger scale at the level of the wholesaler that supplied them.



Source: own study

Graph 1. Status of orders in Simulation 1
Graf.1. Status zamówień w Symulacji Nr 1



Source: own study

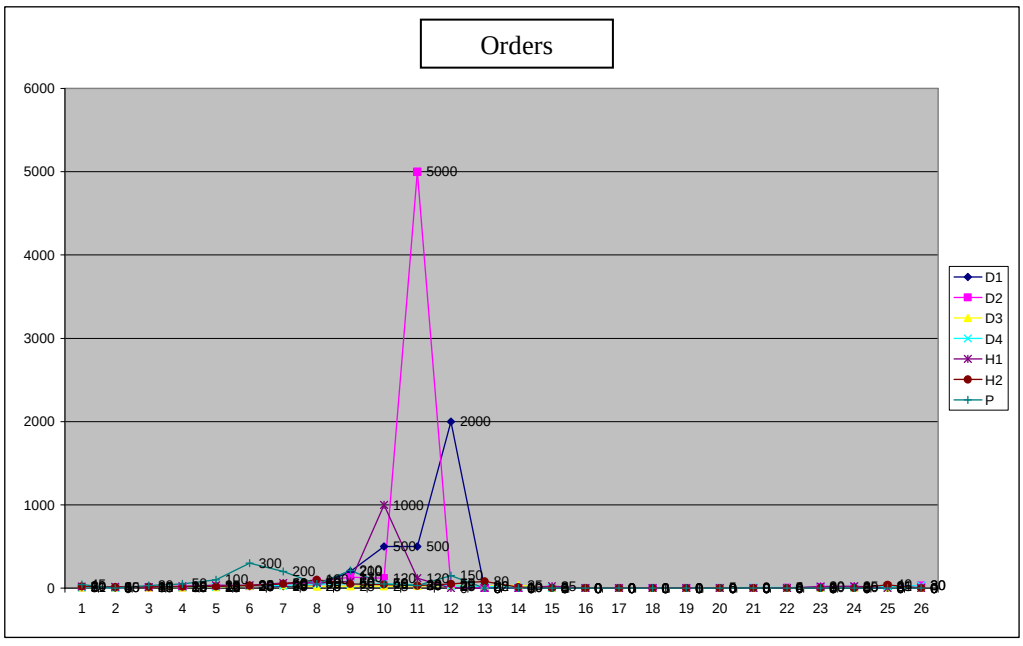
Graph 2. Closing stock in Simulation 1
Graf.2. Zapas końcowy w Symulacji Nr 1

SIMULATION 2 - AMATEURS

In this simulation, wholesaler No. 1 was the first to take a risk and make a significant change to the operational strategy - he placed a truly astronomical order. This line of action was also pursued (after a few rounds) by his retailers. This resulted in achieving a definitely higher level of covering the demand in that part of the supply chain (retailers No. 1 and 2 were permanently assigned to wholesaler No. 1). In consequence, that branch of the supply chain took over virtually all the stock gathered in the producer's warehouse. Also, the manufacturer took advantage of this situation, as his achievements were partially dependent on decisions made by wholesaler No. 1.

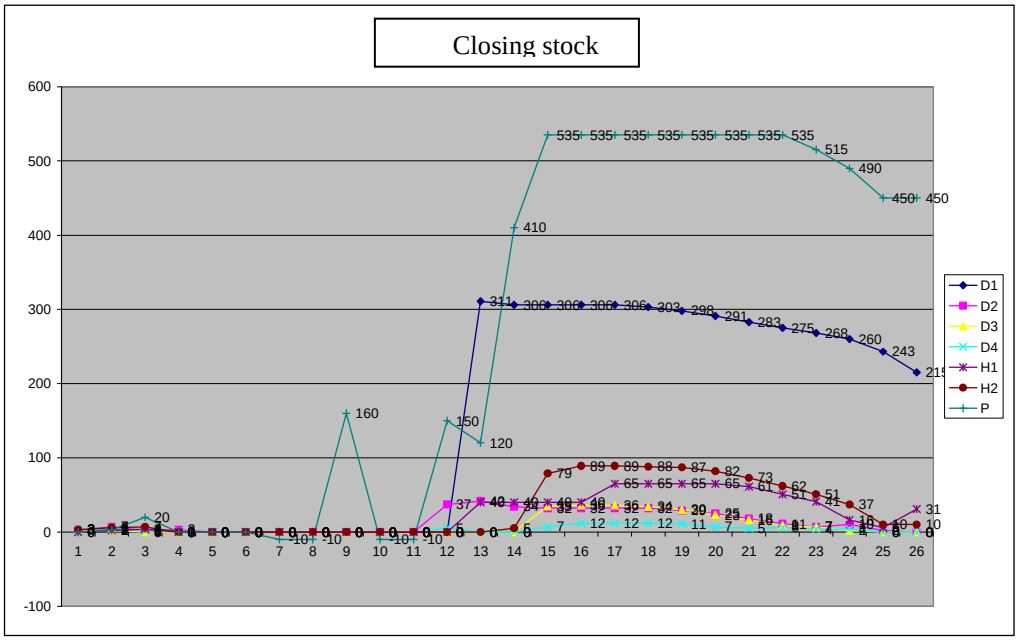
Retailers No. 3 and 4 adopted the strategy consisting in adjusting the orders volume to the demand profile. A similar course of action was followed by wholesaler No. 2 who was responsible for supplying them. However, in this case (the downstream side of the supply chain), ordering relatively smaller volumes led to receiving relatively smaller quantities, compared to the aggressive policy carried out on the upward side of the supply chain. In this context, the results obtained by the other branch of the supply chain (retailers No. 3 and 4 and wholesaler No. 2) should be considered average. As a result of market conditions development (orders placed and deliveries fulfilled), wholesaler no. 2 was caught between the rock - the dominating branch of the supply chain, and a hard place - terms offered by the manufacturer.

The closing stock was a result of the orders which had been placed in the previous rounds. Retailer no. 1 was the first to build up increased stock. Although he did not order extreme volumes that were known to have been ordered in the game, he managed to take over single-handedly the major reserves of goods in the network. Therefore, although he played the role of a retailer, he effectively became a wholesale intermediary. The stock levels of other retailers were lower than those of wholesalers, which was some kind of regularity. As usual, the results obtained by the manufacturer with regard to stock management are the least advantageous. The bullwhip effect is the most powerful at the manufacturer's level.



Source: own study

Graph 3. Status of orders in Simulation 2
Graf.3. Status zamówień w Symulacji Nr 2



Source: own study

Graph 4. Closing stock in Simulation 2
Graf.4. Zapas końcowy w Symulacji Nr 2

To conclude, retailer No. 1 created a large stock by placing excessive orders, which in the end contributed to his falling to the last rank. However, his actions also contributed to the spectacular success achieved by wholesaler no. 1, who placed similar orders, but was able to sell them off at the same time to retailer no. 1, who generated the above-average demand.

CONCLUSIONS

The final results show the systemic domination of some elements of the supply system over the other. The final result achieved by each of the participants depended on timely decisions to place orders in adequate volumes and receiving appropriate levels of supplies, combined with a possibility to sell the stocks off during the simulation. The problem to be solved was determining (forecasting) the right order (delivery) volume.

In both cases of the simulation game the rules were the same. The only variable which was subject to an additional analysis was the delivery cycle which was twice shorter in the case of the latter simulation. The analysis of the simulation results shows that shortening the delivery cycle (the cycle of suppliers' responding to the customers' signals) promotes improvement of the goods stream flow speed. The signal propagation takes place faster in such a case, so it is possible to adjust faster to the new situation on the market.

In the first simulation, where the delivery cycle is twice as long, the entities cooperated with each other on the push principle. The goods stream flow was definitely pushed, and the individual entities being parts of the chain tried to move the burden of the stock onto their cooperator. Shortening the response cycle (the other simulation) facilitated the transformation into the pull flow. In this case, there already are some significant connections of the supply with the demand, which are particularly noticeable in the relationships of retailers and wholesalers, where deliveries are pulled from wholesalers by means of retailers' signals in a maximally shortest time (the time bucket equaling one week).

Assuming the stationary quality of the distribution network architecture, subsequent activities will be targeted at further reduction of the delivery cycle. Introducing openness of information on resources in the distribution network will contribute to their better circulation. In a long run it might be necessary to consider introducing e.g. VMI - vendor manage inventory. However, in such a case the classical rules of the beer game will no longer apply and the game as such will no longer be useful.

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ANALIZA ZJAWISKA BICZA FORRESTERA W SIECI DYSTRYBUCJI - KONKLUZJE Z SYMULACJI "GRA PIWNA"

STRESZCZENIE. Współcześnie obserwujemy wzrost rozmaitych form współpracy między przedsiębiorstwami, zróżnicowanych zarówno, co do stopnia integracji partnerów jak i intensywności kontaktu. Mimo to w dobie lokalnych i globalnych łańcuchów dostaw stare nawyki (atawizmy postępowania biznesowego) pozostają. Efekt byczego bicza (bicza Forrestera) występuje nieustannie z większą bądź mniejszą siłą w codziennej rzeczywistości gospodarczej. Paradoksalne jest to (samospełniające się proroctwo), iż chociaż mechanizm jego działania wydaje się być znany, to praktyka dowodzi, iż partykularne interesy partnerów (lokalne zwycięstwa) bardzo silnie wpływają na podejmowane decyzje. Wydaje się to jak najbardziej prawidłowe w dzisiejszych czasach na rynku, na którym toczy się totalna walka konkurencyjna. Tyle, że to, co korzystne dla jednego z ogniw łańcucha, może być wręcz zabójcze dla całej sieci dostaw (brak zwycięstwa zespołowego). Z jednej strony teoria, zaś z drugiej praktyka - własne badania zjawiska wśród amatorów oraz znawców problemu, stanowią przyczynek do wyprowadzenia wniosków płynących z analizy. Spostrzeżenia prezentowane są przez pryzmat psychologii ludzkiego działania (konieczność podejmowania decyzji), kwestii tak silnie wpisanej w naturę człowieka. Kanwę opracowania stanowią badania optymalizacji strumieni materiałowych w logistyce dystrybucji, prowadzone przez autorów w ramach projektu naukowego Katedry Systemów Logistycznych.

Słowa kluczowe: fizyczna dystrybucja, sieć (łańcuch) dostaw, efekt byczego bicza (bullwhip effect), efekt (bicza) Forrestera, gra piwna (beer game), symulacja.

ANALYSE DES FORRESTER-EFFEKTS (BULLWHIP-EFFEKT) IM DISTRIBUTIONSNETZ - SCHLUSSFOLGERUNGEN AUS DER SIMULATION EINES "BIERVERTRIEBS-SPIELS"

ZUSAMMENFASSUNG. Gegenwärtig beobachten wir Zunahme von verschiedenen Formen der Zusammenarbeit zwischen unterschiedlichen Unternehmen. Die Kooperationsformen sind differenziert in Bezug sowohl auf den Grad der Integration zwischen den Partnern, als auch auf die Intensität der betreffenden Kontakte. Unabhängig davon bleiben im Zeitalter des Bestehens lokaler und globaler Lieferketten alte Gewohnheiten (Atavismen im Geschäftsverhalten) lebendig. Der Effekt der Bullenpeitsche (der Forrester-Effekt) tritt ununterbrochen mit größerer oder kleinerer Intensität in der täglichen Wirtschaftsrealität auf. Obwohl die Wirkung des Forrester-Effekts allgemein bekannt ist, die Praxis beweist jedoch, dass die eigenen partikulären Interessen der Partner (lokale Siege) sehr stark die von ihnen zu treffenden Entscheidungen beeinflussen, obwohl dies wie auch immer paradox (ein sich selbst erfüllendes Orakel) zu sein scheint. Im totalen, auf dem heutigen Markt herrschenden Wettbewerbskampf scheint ebenfalls ein solches Verhalten durchaus richtig zu sein. Es darf aber dabei nicht außer Acht gelassen werden, dass das, was für ein Glied der Lieferkette nützlich ist, für das ganze Distributionsnetz sich als tödlich erweisen kann (Ausbleiben von Team-Siegen). Einerseits also die Theorie, andererseits die Praxis - eigene Erforschung dieser Erscheinung unter Laien und Sachkennern leistet einen Beitrag zur möglichen Schlussfolgerung anhand der betreffenden Analyse. Die Einblicke werden vom Gesichtspunkt der Psychologie menschlicher Handlungen (Bedürfnis nach Entscheidungstreffen), was in die Natur der Menschen so stark eingeprägt ist, präsentiert. Als Basis für diese Bearbeitung bestehen Forschungen zur Optimierung von Material-Strömen innerhalb der Distributionslogistik, welche von den Autoren im Rahmen eines wissenschaftlichen Projektes am Lehrstuhl für Logistik-Systeme durchgeführt werden.

Codewörter: physische Distribution, Lieferkette, Bullwhip-Effekt, Forrester Effekt, "Biervertriebs-Spiel" (Biervertriebs-Spiel), Simulation.

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