Time Dependencies in Supply Chain Perfomance Process

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The paper focuses on basic time relations within the range of a supply chain. Relations occuring between effective, constant realization of operation task and logistics are determined. Fundamental time delays affecting added value of logistics chain are discussed. On the example of a particular production system evaluation capabilities of particular time parameters are pointed out.

1. INTRODUCTION

The character of production capabilities and distribution capabilities of expansive logistics systems/networks or supply chains requires appropriate definition of i.a. time relations occuring between system facilities and its processes.

Time delays issue is typical for many physical or technical systems and raises a point in i.a. biology, engineering or economics [10]. In the 70s' of XXth cen. the concept of time delays - Delay Operator - was applied in time analyses in modelling or forecasting processes [3]. In consecutive years there occured writings on time relations in other research areas, e.g. in modelling logistics and technical facilities maintenance processes. A review of fundamental research issues associated with modelling time relations of operational systems is presented in figure 1.

In the 80s' of the XXth century, Christer and Waller [7] suggested a concept of time delays - Delay-time Concept (DTC) – applied to the present day in replacement processes theory in order to improve operating inability of technical system caused by its untimely detected damage (improvement of the period between successive inspections). By this concept, a period of time from the moment (u) when first detectable symptoms of a damage start to occur during periodic inspection, until the moment when the system becomes impaired, is called delay time and is marked with h (fig. 2.)

Until now a series of articles have been published on implementing DT concept in the performance area of actual systems, i.a. to solve the issue of processing machines operation (e.g. [1, 5]). Models well described in special literature are based on typical preventive service strategies (e.g. [15]) and condition-based maintenance strategy (e.g. [6, 17]). Other applications refer to i.a. construction (e.g. [8]), or transport (e.g. [9, 12]).

Fundamental questions which demanded answers were as follows [4]:

- How often should the vehicles be repaired, periodically inspected?
- Is the technical system structure safe?
- How often should periodic inspection be performed of production line appliances?
- What is the benefit of performing maintenane processes with regard to system inability time and operating costs?

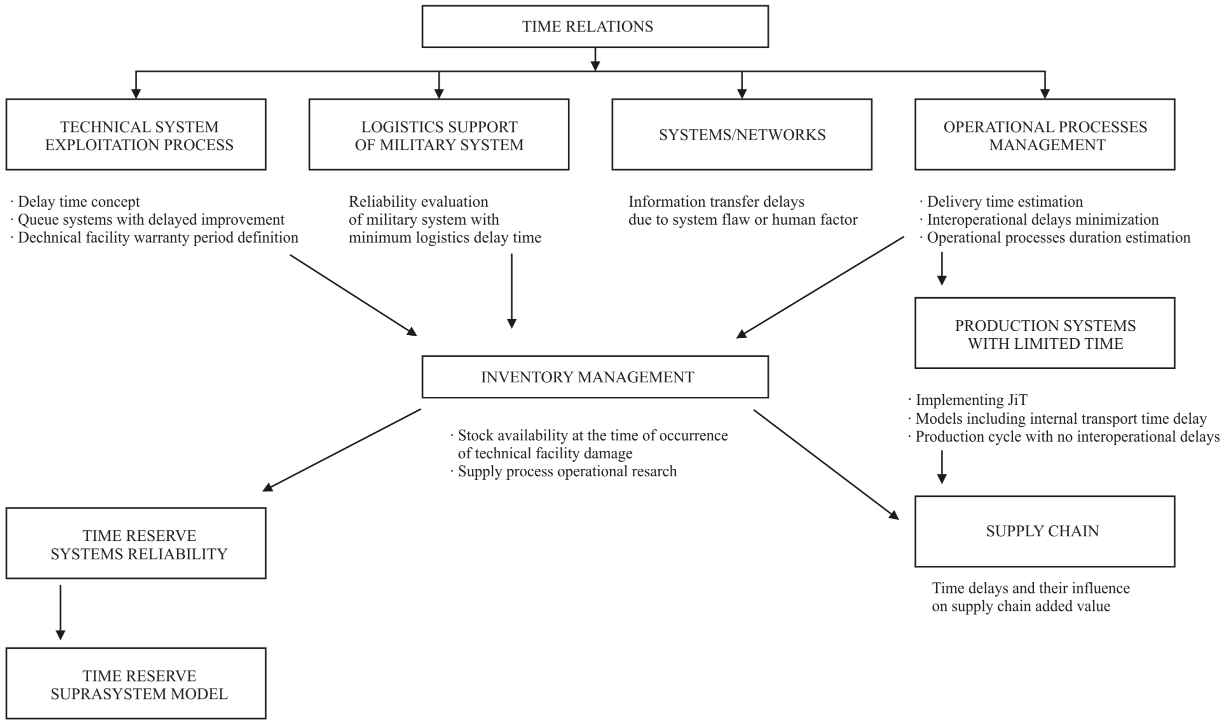

Fig.1 Time relations in operational systems performance process.

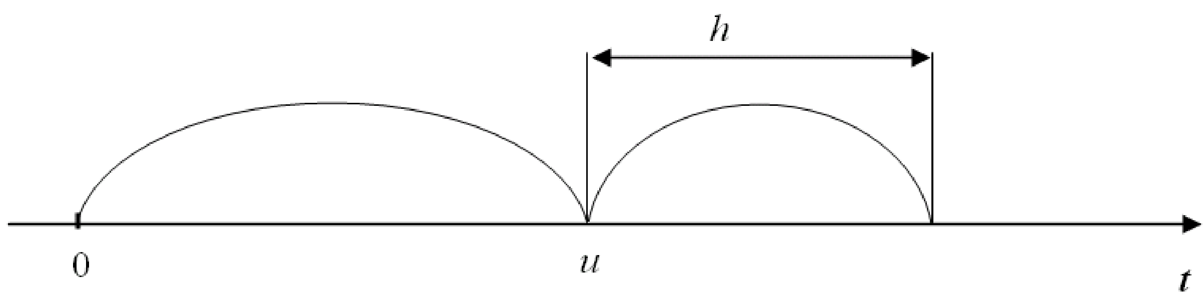

Fig. 2. Time delay concept [7]

A review on present DT models can be found in [4, 13].

At the same time, when examinig the problematic aspects of time dependencies, one must take into consideration the notion of logistics delays occuring in performance process of military technical systems [16]. Fundamental issue in this area is the assessment of the influence of logistic delay on military system inability time (repair delay time occurs due to the lack of replacement parts), and consequently on its standard reliability rates [18].

Military approach has also been implemented to solve the issue of working time of production and technical systems, regarding i.a. [18]:

- Interoperational delays
- Random delivery time,
- Stock availability.

An example can be the model of suprasystem with time reserve presented in the work [18], including the possibility of logistics system operating inability in the exploitation process of a supported system and allowing the assessment of the influence of supporting system failure on general reliability and economics character of an examined suprasystem.

At present, with progressing competition there emerged the issue of complete integration of systems cooperating within a supply chain and elimination of any time delays affecting product added value [2]. It is necessary to include a range of time parametres affecting fundamental quality of a supply chain [14], therefore further in the paper the focus is on presenting main time dependencies occuring in its performance process as well as on genuine production system functioning and the assessment of distribution processes from the perspective of their time dependecies.

2. TIME DEPENDENCIES IN SUPPLY CHAIN

In logistics chains an accurate definition and identification of operating value chain, with particular emphasis on delivery time and time relations is particularly important. In the integration process of present operational processes along a supply chain, where numerous suppliers (raw materials, semi-finished goods) cooperate in order to deliver a finished product to the customer, any time delays considerably affect the performance quality and can be reduced i.a. through appropriate actions targeted at improving fundamental reliability features of supply chain [14] (fig. 3).

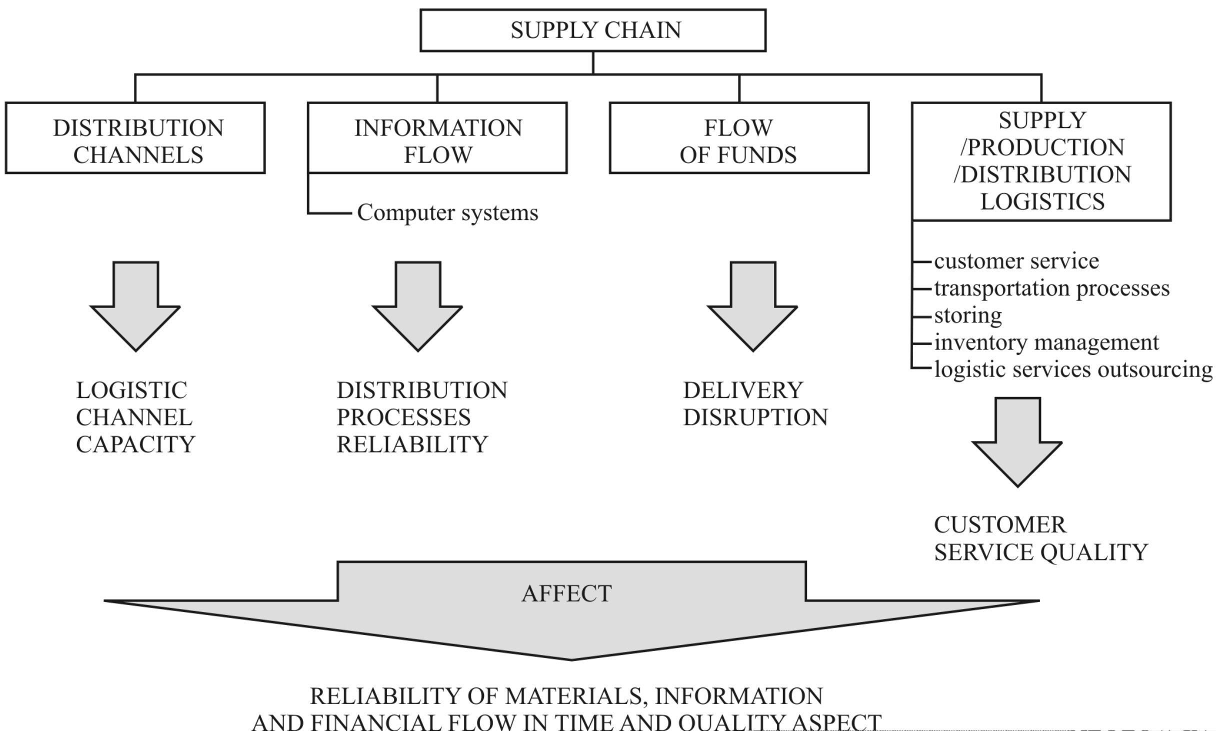

Fig. 3. Time relations in supply chain

In standard supply chain there are distinguished particular operational cells, between which fundamental material and information flows occur (fig. 4). With each cell one could speak of incurring specific costs and increasing added value for a final customer. At the same time each unit is characteristic for:

- stochastic demand,
- a defined level of stock compatible with selected re-stocking policy,
- limited capacity,
- limited transportation capabilities,
- random delivery time,
- required customer service degree,
- the extent of material and information flow.

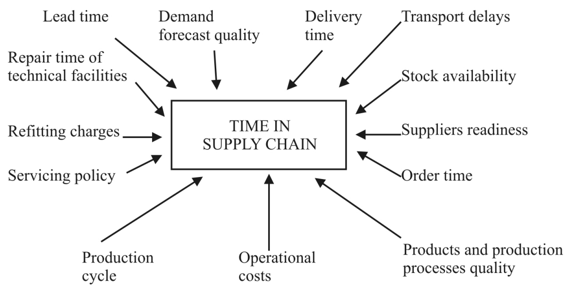

Fig. 4. Time in supply chain

Consequently, in order to manage time effectively in supply chain and to reduce delivery time and any delays, the following are usually applied:

- modern concepts of logistics management such as Quick Response, Just in Time, or Lean Management;
- modern communication technologies.

At the same time, fundamental decision variables analyzed by the managing board of operating supply chain are as follows:

- When to produce?
- How much to produce?
- How much and where to invest to shorten delivery time effectively?
- in order to:
- maintain minimum stock in supply chain,
- deliver goods to the final customer asap.
- At present, the issue of inventory management and delivery time improvement is extensively analyzed in literature [18]. A review of inventory management models can be found in [11, 18].

Usually in actual supply chains, time estimation of executed logistics processes consists in analyzing delivery effectiveness with regard to promptness of customer's order completion, or delivery quality in reference to properness or flexibility [14]. On the other hand, one can observe express reluctance of companies to the assessment of operational and management capability of logistics infrastructure operating within an entire supply chain. It is the effect of the necessity to gain much additional information, which until now was not collected in systems, and to make it available to other participants of supply chain.

3. AN EXAMPLE OF ASSESSMENT OF LOGISTICS SYSTEM PERFORMANCE

The production enterprise under examination is a participant of international logistics chain whose objective is to supply the market with electrical wiring and fittings [19]. The company offer lists over 7200 products oriented on satisfying energy demand and also on securing the wiring in housing, general and industrial construction.

Main market for these goods is located in the West Europe. In Poland these products are available through so called active distributors, and supermarkets. At the same time logistics supply chain (fig. 5) encompasses raw materials supply, production and indirect distribution processes. Transport is handled by company appointed logistics forwarder. The process of customer's order handling is featured in figure 6.

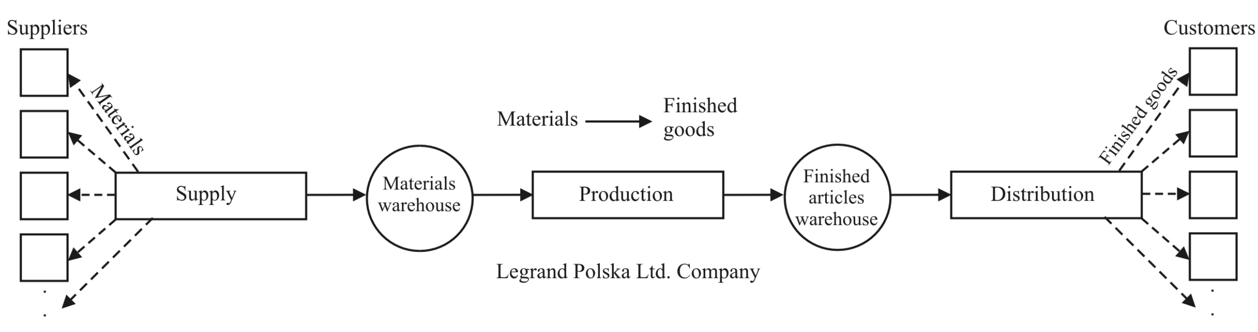

Fig. 5. Supply chain of analyzed company [19]

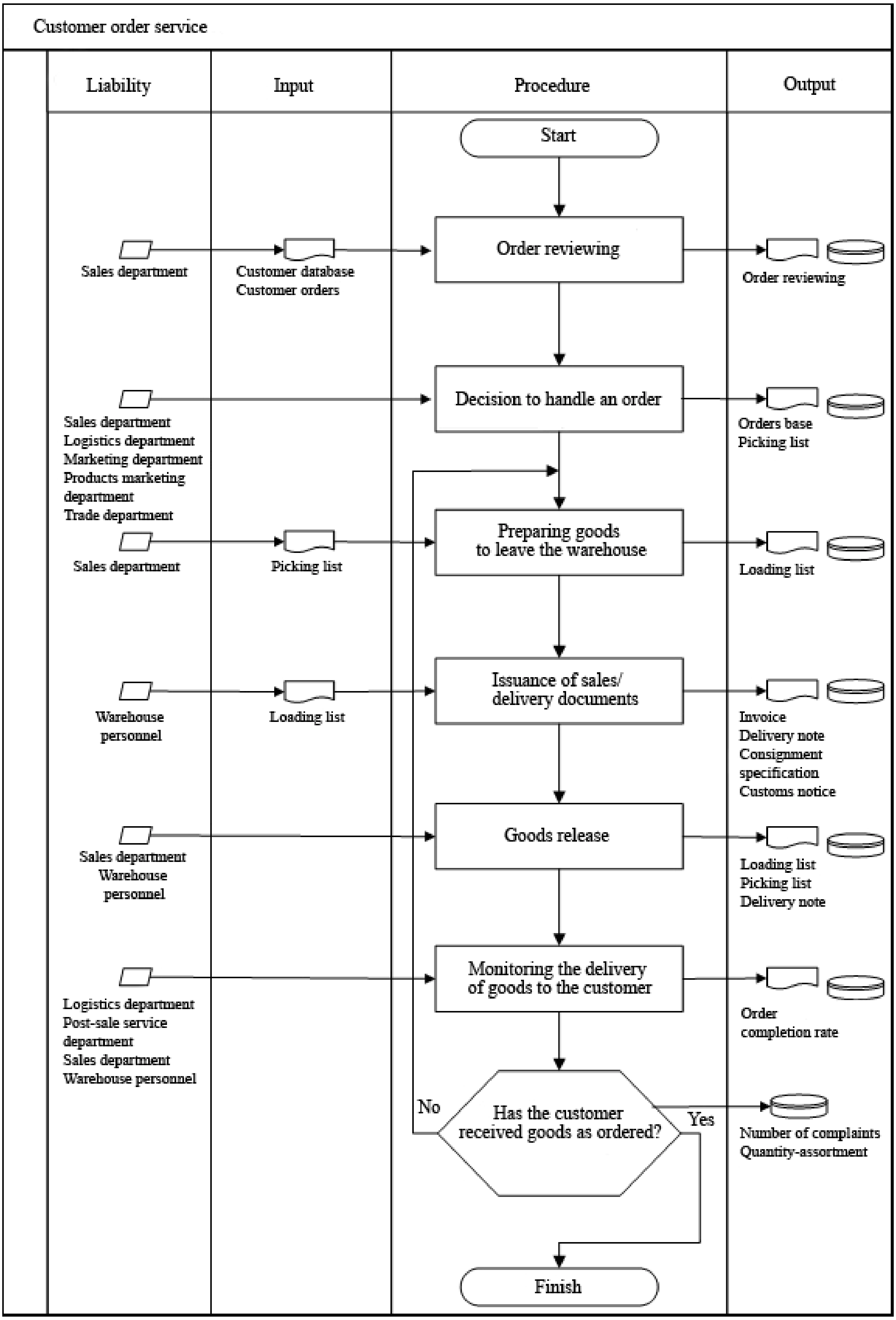

Fig. 6. Customer order performance process in analyzed company [19]

The process of accepting and fulfilling an order starts at the very moment of its receiving. Order handling is performed by trade personnel. From the date of order receiving a company has 48h to fulfill it and another 24h to transport it to the customer. Hence, estimated delivery time, which is the period from order receiving to goods delivery, is 72h. However, there are situations when delivery time oscillates between 24 ÷ 120h.

The performance analysis of the discussed logistic system in the selected company was mainly conducted on the basis of actual data of 2008, collected in company records (table 1).

Table. 1. Main logistic measures used in analyzed company [19]

No.	Measure description	Measure evaluation model	Measurement unit
1	Average order fulfillment time	The period of order placement to delivery consignment	h
2	Average goods delivery time	The period of order accepting until delivering goods to the customer (preparing the delivery for unpacking at the customer's)	Days
3	Order fulfillment rate	Number of orders fulfilled /placed	%
4	Perfect order fulfillment time	Number of perfect orders fulfilled /orders in general	%
5	Perfect delivery completing time	Number of perfect deliveries of goods fulfilled/deliveries in general	%
6	Supply forwardness	(the number of instantly handled orders /number of orders)*100	%
7	Delivery reliability	(reliable delivery of goods / delivery in general)*100	%
8	Faulty delivery of goods	(a number of faulty delivery of goods / delivery in general)*100	%
9	Delayed delivery of goods	(a number of delayed delivery of goods / delivery in general)*100	%
10	Complaint Delivery of goods	(a number of complaint delivery of goods / delivery in general)*100	%

First and foremost the issue of customer order fulfillment in a company was assessed. Collective value of logistics measures are presented in table 2, dynamic approach of order fulfillment rate has been presented in figure 7.

Order fulfillment rate is striking – it is merely 58%. What it means is that a company is not capable of completing a considerable part of all orders. This can be associated with a shortage of goods ordered, which consequently can lead to customer cancelling the purchase, if the company is not in or is incapable of providing required quantity of goods. This assertion is also confirmed by a company's low supply forwardness. Such a situation can be improved by conducting ABC/XYZ analysis which helps to identify the products predisposed for higher reserves in stock. Furthermore, reserves control procedures implemented in a company should be analyzed.

It is also advisable to observe the forwardness of fulfilled orders (table 3). One can notice that for successive quarters of the year 2008 the average order fulfillment time is very different. One of the reasons is the change of policy towards the notion of immediate order fulfillment during calendar year, which directly affected na zmianę mechanizmu jego pomiaru, and consequently resulted in occuring variance of obtained results.

Customer order fulfillment times in the last quarter of 2008 are presented in table 4.

Table 2. Values of main logistic measures used in analyzed company in 2008 [19]

No.	Measure	Result acquired
1	Order fulfillment measure	58%
2	Perfect order fulfillment	71%
3	Behind-schedule order fulfillment	29%
4	Supply forwardness	8%
5	Delivery reliability	91%

Table 3. Average times of order fulfillment and perfect order fulfillment for four following quarters in 2008 [19]

Quarter	Average order fulfillment time [h]	Perfect orders fulfillment rate
1	23	93%
2	45	84%
3	58	56%
4	62	50%

Table 4. Time of order fulfillment in the fourth quarter. [19]

Time of order fulfillment in the fourth quarter [h]	Number of recipients
Immediate fulfillment	0
24	791
48	2456
72	1964
>72	1310
total	6521

Table 5. Main values of logistic measures used in analyzed company in 2008 [19]

Measure type	Result
Invalid delivery of goods	0,18%
Complaint delivery of goods	0,01%
Perfect delivery	99,9%

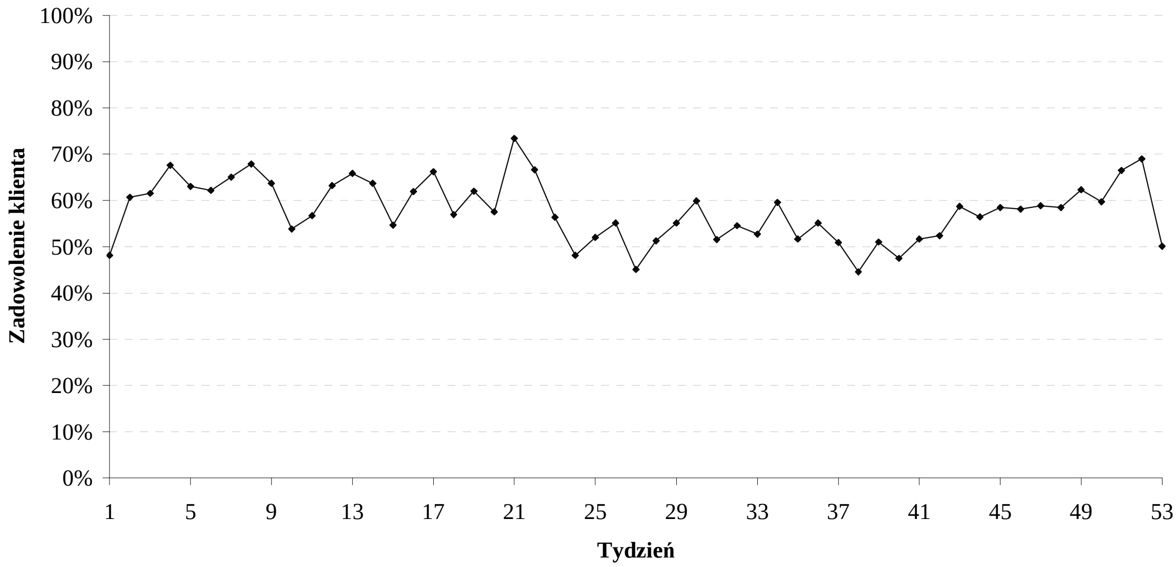

Fig. 7. Perfect order fulfillment [19]

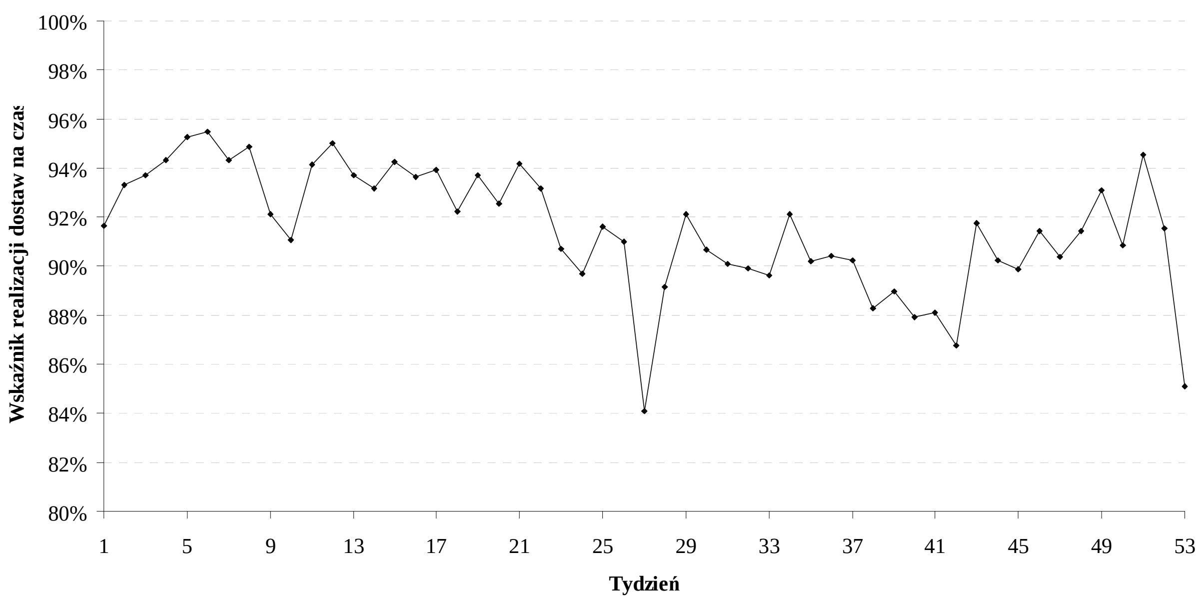

Fig. 8. Level of on-time delivery performance. [19]

The level of delivery performance for particular weeks in 2008 is comprised in figure 8.

As comprised in the graph, the optimum delivery performance of 95% was reached by the company in the sixth week, the worst 84% in the 27th week in summer time when the demand for specific products is higher.Another issue is the quality of performed delivery (table 5).

By the results obtained, one can assert that in 2008 very few invalid deliveries of goods were performed. However, a particular focus should be on the cause for these failures. Even the smallest failure evokes delivery complaint and what follows lesser customer satisfaction and loyalty. Average invalid delivery measure of 0,18% exceeded legitimate value of 0,17% and can constitute the basis for actions targeted at readjusting the process of product preparing for further transport in order to avoid undesirable occurrence in the future.

The analysis of obtained results leads to the focus on three fundamental issues in the field of distribution logistics:

- very long lead time often exceeding base time;
- low delivery forwardness which can point out unreasonable inventory management;
- low order fulfillment rate.

4. CONCLUSION

At present one can observe growing awareness of management boards in the field of effective time management in logistics chain. However, the issue remains the lack of accurate identification of elementary time dependencies occuring in supply chain. Time relations in logistics chains are usually analysed in the context of possible damages or delivery delays because their influence on customer order fulfillment is indisputable and familiar. At the same time companies do not usually notice the necessity to evaluate logistic processes performance across entire chain, which is repeatedly associated with additional data collecting and making it available to other participants of logistics chain.

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