The Improvement of the Supply Process for the Variable Demand Goods

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As the customer-oriented policy appears to be the prevailing attitude nowadays, none of companies can afford to seek savings in the field of customer service. As a result, all supply-related processes remain in the spotlight. Until recently this area has been oftentimes neglected by Polish companies but at present it is perceived as the area which allows the capital to be released.
The main issue discussed in the below article is the question of strategic sourcing and inventory management. The article aims at characterizing strategic sourcing problems the discussed company struggled with. It also presents the suggested model of stock control, which is being implemented at present.

1. STOCK MANAGEMENT WITHIN SUPPLY LOGISTICS.

Completeness, quality and timely manner of deliveries remain the key issues as far as purchasing processes are concerned, as they determine efficiency of production processes[1]. Therefore, one of the tasks ahead of logistics is to maintain minimum stock and undisturbed flow of materials at the same time. It is achieved by means of:

- proper material demand planning;
- taking pertinent decisions as far as deliveries' size and frequency are concerned;
- well organized material flow between a supplier and a company; also inside a company.

Material demand planning is definitely one of the key issues dealt with by supply logistics[2]. However, applying the correct system of purchasing planning depends largely on the information decision makers possess. There are two main types of basic data that can be distinguished[3]:

- the exact information resulting from the direct calculations of expected materials consumption due to production (MRP inventory management)[4];
- statistical information on expected demand, gathered on the basis of stock changes observations (traditional stock replenishment).

As the project described in the second part of the article refers to traditional stock maintenance[5], these solutions will be dealt with. Within the

[1] Skowronek C., Sarjusz – Wolski Z., *Logistyka w przedsiębiorstwie*, Polskie Wydawnictwo Ekonomiczne, Warszawa 2003

[2] Zielonka A., *Cele, przedmiot i czynności gospodarki materiałowej*, „Gospodarka Materiałowa i Logistyka 1997, nr 10, p. 216

[3] Krawczyk S., *Zarządzanie procesami logistycznymi*, Polskie Wydawnictwo Ekonomiczne, Warszawa 2001

[4] Bozarth C., Handfield R.B. *Wprowadzenie do zarządzania operacjami i łańcuchem dostaw* ONE Press, Helion, Gliwice 2007

[5] *Buxey G.,* Reconstructing inventory management theory, *International Journal of Operations & Production Management, Year: 2006, Vol. 26, Issue 9, p. 996-1012*

research carried decisions will be taken as far as size and frequency of deliveries are concerned, i.e. stock replenishment planning. It results from demand variability and the fact that production plans must be constantly updated. Production plans are prepared on weekly basis. As a consequence specific parameters are necessary to manage stock and to place relevant orders[6].

The main idea for the traditional sourcing for one material is to indicate a pattern which will be the basis for orders parameters[7]. There are two key parameters that need to be indicated – the time and the size of an order. Basing on the two key parameters two benchmark models of stock control were created[8]:

- re-order point and
- re-order cycle.

Re-order point, also known as stock replenishment system, is based on information level or policy (s, Q)[9]. In the above mentioned model two control parameters are determined[10]:

s – information level , also called an alarm level, a level of re-ordering or reasonable safety stock;

Q – delivery (order) size, which can be constant or variable.

In professional literature we can find concepts of static and dynamic order sizes[11]. Static order sizes are understood as those that remain unchanged after any single calculation. Dynamic sizes however, undergo constant re-calculation along changes in net demand.

Policy (s, Q) assumes that when the stock reaches information level (or goes below) the provider will receive a Q-size order.

A model of permanent ordering cycle, also called a periodical overview-based system[12] or policy (T, S)[13], bases also on two control values[14]:

T – overview cycle, also called an optimal ordering cycle, which is a permanent period of time between succeeding orders;

S – maximum admissible stock, also called a rational top stock, which serves the purpose of calculating the size of each order.

In policy (T,S) order are placed according to a specific Schedule, resulting from the overview cycle. The order size is calculated as a difference between assumed maximum and current stocks[15].

If we combine the two models we will receive MIN – MAX strategy, which bases on two parameters (s, S)[16]. That means that both maximum admissible stock level and information level are calculated. In the system the stock level is controlled all the time, and when the stock goes below alarm level, an order is sent. Its size results from the difference between a maximum admissible stock and calculated currents stock.

2. RESEARCH PROJECT FOR THE STOCK MANAGEMENT AT THE HAIRDRESSERS' FURNITURE PRODUCER

2.1. THE ANALYSIS OF THE EXISTING CONDITION

Managing the stock of materials will be presented on the example of hairdressers' furniture producer. The company in question is a leader on its market and their products are sold both locally and abroad. The managing board of the company

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[6] Mak K.L., Hung C.H. , A Simple Model for Computing (s, S) Inventory Policies when Demand is Lumpy, *International Journal of Operations & Production Management*, Year: 1986, Vol. 6, Issue 2, p. 62-68

[7] Kczyk S., Metody ilościowe w logistyce (przedsiębiorstwa), Wydawnictwo C.H. Beck, Warszawa 2001

[8] Skowronek C., Sarjusz – Wolski Z., Logistyka w przedsiębiorstwie, Polskie Wydawnictwo Ekonomiczne, Warszawa 2003

[9] Krzyżaniak S., Cyplik P., Zapasy i magazynowanie. Tom I. Zapasy, Wydawnictwo ILiM, Poznań 2008

[10] There

[11] Czerska J., Metody ustalania wielkości partii dostawy, http://www.zie.pg.gda.pl, > (15.08.2009)

[12] Krzyżaniak S., Cyplik P., Zapasy i magazynowanie. Tom I. Zapasy, Wydawnictwo ILiM, Poznań 2008

[13] Krawczyk S., Metody ilościowe w logistyce (przedsiębiorstwa), Wydawnictwo C.H. Beck, Warszawa 2001

[14] There

[15] Krzyżaniak S., Cyplik P., Zapasy i magazynowanie. Tom I. Zapasy, Wydawnictwo ILiM, Poznań 2008

[16] There

decided to seek some savings in the times of crisis and therefore internal processes were improved and excess expenditures were eliminated e.g. high stock levels. The project aiming at material flow improvement was started and the authors of this article were invited to join it.

The first stage of the project realization was auditing of the current process and it included the following:

1. the effective rules of stock management and strategic sourcing in use;
2. the rules that determine stock management parameters, especially alarm level and delivery size;
3. past data about the demand;
4. stock levels versus consumption.

As a result of the carried analysis, the following situation was observed:

1. Although production runs in *pull* system (against customer's order) materials are purchased according to classic systems of stock replenishment (keeping stock in a warehouse). The main controlling parameter is information level *s*, which triggers order placement at the supplier. Stock replenishment procedures are started once stock level falls below alarm level. Each material has its own defined minimum stock level. It is of static nature and does not change over the year. According to the analysis that was carried, the information level which is used nowadays was established in 2005, when ERP system was introduced, and has not been modified since then.
2. In the production plant there are three production departments where subsequent stages of production take place. Each of these departments purchases materials individually, according to their individual needs. Heads of the departments are responsible for supply process and they do not consult one another while placing their orders. As a result of such decentralization the production plant does not make any use of the economies of scale, as orders placed by department individually are of "fragmented" nature.
3. Alarm levels were defined in the system a few years ago and heads of department determined them intuitively. When the order is placed, the size of delivery is also established basing on the each head's knowledge and experience. As a result some of the stocks are too high while others show shortages. The size of delivery is not of permanent nature.
4. From the analysis of the past data it can be observed that there are certain material indexes in each production department for which the alarm level is either under- or overestimated to a very high extend. At the same time it has been noticed that consumption of certain materials depends on season, which information is not taken into account in stock replenishment system.
5. The project concentrated mainly on the material reserves kept in particular departments. The inventory taken in a warehouse proved that for many material indexes the stock is either too high or too low. As the purchasing process is run by experienced employees who are supported by IT system, the authors of the text suggested that probably alarm levels that trigger order placement were wrongly defined. Therefore the effort was made to analyse alarm levels for each individual material index. The results of the research carried in department number 3 will be shown in this article.
6. Data referring to material consumption are registered in the system on a monthly basis. Hence, monthly demand figures were analysed. An estimated alarm level is given for each material index. In case of materials with low consumption, the information level stock can be described as zero. The date of filling the order is known to people responsible for stock maintenance (however, it is not entered into the system).

The analysis of the present figures included materials with minimum stock over zero. As a result 188 indexes were examined and the procedure proceeded as follows:

- STEP 1: calculation of average monthly consumption of a given material for 2005 – 2008.
- STEP 2: comparison of average monthly consumption in succeeding periods of time with the estimated minimum stock.
- STEP 3: identification of maximum monthly consumption during the period of time in question.
- STEP 4: comparison of maximum monthly consumption during the period of time in question with the estimated minimum stock.

- STEP 5: calculation of minimum stock value on the basis of existing prices.

The average monthly consumption of the analysed material was compared with the estimated alarm level and it clearly proved that in most cases the demand did not exceed the defined *s* level.

The results of the carried analysis are presented in table 1.

Table 1. The percentage of materials from department number 3, with average monthly consumption below alarm level.

year	**2005**	**2006**	**2007**	**2008**
percentage	71,28%	65,43%	67,02%	76,06%

Source: Authors' own data

It must be pointed out that the problem of too high stock level does not refer only to materials with low unit cost prices, but also to those with really high ones. It means that all inaccuracies referring to minimum stock levels result from lack of effective procedure and from negligence. Table 2 presents a choice of materials with definitely too high stock reserves *s*.

Table 2. A comparison of chosen material indexes with an average monthly consumption lower than declared minimum stock.

I[17]	**c [zł/m]**	**s [m]**	**k [zł]**	**a^{05} [m]**	**a^{06} [m]**	**a^{07} [m]**	**a^{08} [m]**
001	163,29	10	1632,90	1,83	1,87	0,91	0,61
002	36,00	10	360,00	3,08	5,08	2,75	3,50
003	59,15	6	354,91	0,89	0,83	0,44	0,35
004	38,81	6	232,86	0,25	0,29	0,70	0,30
005	31,38	6	188,28	0,41	0,00	0,00	0,00
006	22,50	10	225,00	0,25	4,58	0,00	0,00
007	20,45	10	204,50	0,25	4,58	0,00	0,00
008	05,36	60	321,60	00,00	00,00	00,00	07,55
009	13,13	25	328,13	02,20	01,90	01,55	00,40
010	22,00	20	440,00	02,29	01,62	00,89	00,50
011	19,30	20	386,06	00,67	02,63	00,71	00,96
012	16,11	20	322,20	01,79	04,76	08,12	04,10
013	26,04	20	520,78	00,75	02,41	01,51	00,46
014	13,20	20	263,98	00,17	00,02	00,38	00,84
015	26,73	20	534,60	02,41	02,59	03,48	03,27
016	20,74	10	207,40	00,16	00,18	00,23	00,12
017	56,00	20	1120,00	0,00	0,00	0,00	0,00
018	54,00	20	1080,00	0,00	0,00	0,00	0,00
019	60,00	10	600,00	0,00	0,00	0,00	0,00
020	90,00	10	900,00	0,00	0,00	0,00	0,00
021	39,00	20	780,00	0,00	0,00	0,00	0,00

Legend: I – index, c – cost price, s – alarm level, k – alarm level cost, a^{05} – average monthly consumption in 2005

Source: Authors' own data

The next stages of the research proved that 59 indexes out of 188 under examination had minimum stock higher than maximum consumption in 2005-2008, which equals 31% of the examined materials. Table 3 presents the examples of such a situation along with figures for capital frozen in reserve alarm stock.

Table 3 A choice of material indexes with maximum monthly consumption in 2005-2008 was lower than declared minimum stock.

I	**c [zł/m]**	**s [m]**	**$Max^{05\text{-}08}$ [m]**	**k [zł]**
001	163,29	10	7,05	1632,90
003	59,15	6	1,91	354,91
004	38,81	6	3,50	232,86
005	31,38	6	3,08	188,28
006	22,50	10	8,00	225,00
007	20,45	10	8,00	204,50
009	13,13	25	8,28	328,13
010	22,00	20	5,44	440,00
011	19,30	20	12,52	386,06
013	26,04	20	8,64	520,78
014	13,20	20	7,03	263,98
015	26,73	20	16,91	534,60
016	20,74	10	1,43	207,40
017	56,00	20	0,00	1120,00
018	54,00	20	0,00	1080,00
019	60,00	10	0,00	600,00
020	90,00	10	0,00	900,00
021	39,00	20	0,00	780,00

Legend: Max 05-08 – maximum consumption in 2005 – 2008, The remaining figures as in table 2

Source: Authors' own data

The analysis shows also that there are materials with underestimated information stock in the examined department. It was assumed that the estimated stock *s* is insufficient to cover the average monthly demand while handling the order.

[17] The names of material indexes have been encoded.

The indexes given below are the examples of such a situation:

- 0101, with minimum stock of 30, lead-time is 7 days, and average weekly consumption is 50[18];
- 0102, with minimum stock of 60, lead-time is 21 days, and average weekly consumption is 125
- 0103, with minimum stock of 30, lead-time is 7 days, and average weekly consumption is 75.

There aren't many material indexes with reserve stock *s* that was lowered. However, it's worth noticing that products with underestimated minimum stock were those with low cost price. Therefore, keeping stock of such materials does not freeze too much capital. In case of lack of these materials, production is stopped or they must be urgently purchased at higher prices. It proves once again that the system of stock replenishment was malfunctioning in the examined company.

2.2. A SOLUTION OF PROBLEMS APPEARING IN THE AREA OF STOCK REPLENISHMENT.

Basing on the results referring to stock control and on the current purchasing process, the authors suggested two leading solutions:

1. Centralization of purchases for all production departments. In order to reach the economies of scale and to avoid doubled orders to one supplier, sent independently at the same time, it seems reasonable to create a separate unit responsible for purchasing for the whole company. It will allow new distribution of competencies. An independent purchasing unit will take up all duties related to buying processes and hence the heads of production departments will be able to concentrate on their primary tasks in a better way.
2. The introduction of a new stock control system that bases on two parameters – level that triggers an order *s* and maximum stock *S* (policy (*s, S*))[19]. Both parameters are of dynamic nature, which means they are modified depending on demand.

For the needs of the company a special algorism has been worked out, which calculates both basic parameters for stock control. Later it was prepared to function as a support for the existing ERP system. Each of the parameters takes into account not only an average consumption during the last two years but also seasonal factor which is calculated on the basis of past data. The parameters of stock control were calculated on the basis of the below patterns[20]:

$$s = a \cdot t + z \cdot \sigma \cdot \sqrt{t}$$

$$S = a \cdot (t + T) + z \cdot \sigma \cdot \sqrt{t + T}$$

where:
s – alarm level, that triggers an order [pcs.]
S – maximum stock reserve, which is not exceeded [pcs.]
a – average consumption calculated on the basis of past data from the last two years. [pcs.]
t – average lead-time from the last two years [weeks]
T – average time of using the delivery [weeks]
σ – average aberration calculated on the basis of past data from the last two years.
z – safety factor for the defined level of services.

In order to define an average demand a two-year period of time was used, due to dynamic changes in the production department of the company. Basing on the past data a seasonal character of demand for some materials was observed. Therfore, both alarm and maximum level were corrected including the seasonal fluctuations.

Before the algorisms were implemented into the current system of the company, they were tested against past data from 2008. From the very beginning calculable results could be observed,

[18] An average weekly consumption was calculated here on the basis of average monthly consumption and then divided by four. It is a kind of simplification that was introduced in order to unify the time parameter. It was necessary due to weekly lead-time deliveries, which are used in prepared algorisms.

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[19] Mak K.L., Hung C.H. , *A Simple Model for Computing (s, S) Inventory Policies when Demand is Lumpy,* International Journal of Operations & Production Management, Year: 1986, Vol. 6, Issue 2, p. 62-68

[20] Krzyżaniak S., Cyplik P., *Zapasy i magazynowanie. Tom I. Zapasy*, Wydawnictwo ILiM, Poznań 2008

especially for those material indexes which stock was definitely under- or overestimated. In case of indexes with too high alarm levels, their stock was lowered, or even reduced completely at times. Three selected positions from table 2 are shown below – they all had too high cost of stock reserves and hence new alarm levels were defined for them.

Table 4 New alarm stocks for chosen indexes along with a comparison of capital frozen in information reserves.

New alarm stock in a month	Index 001	Index 015	Index 010
January	0	1	2
February	0	2	0
March	0	5	0
April	1	1	1
May	2	0	0
June	0	2	0
July	0	3	1
August	1	0	3
September	1	0	1
October	0	0	2
November	1	0	0
December	0	1	1
Unit cost price	163,29 zł	26,73 zł	22,00 zł
Cost of capital in a year frozen in information reserve **in the new solution**	979,74 zł	400,95 zł	242,00 zł
Cost of capital in a year frozen in information reserve **in the previous system.**	19594,80 zł	6415,20 zł	5280,00 zł

Source: Authors' own data

The three exemplary indexes shown in table 4 are just an introduction to possible savings that a company can achieve when implementing new stock replenishment system. It must be stressed out that relatively short lead-times from the suppliers and a variable nature of demand for certain indexes result in a fact, that there is no need to freeze any capital in alarm reserve during given months.

Also the indexes with too low alarm stock need to be reviewed carefully. Three indexes were examined and the results can be seen above.

Table 5 Alarm stock defined for the chosen material indexes.

month	**Index 0101**	**Index 0102**	**Index 0103**
I	62	139	137
II	54	366	142
III	49	395	124
IV	62	425	125
V	64	423	166
VI	68	692	79
VII	87	501	166
VIII	54	450	176
IX	54	519	89
X	36	578	92
XI	61	309	104
XII	66	294	107
A	1	3	1
B	50	125	75

Legend: A – lead-time at the supplier (in weeks),
B – average weekly demand for the material
Source: Authors' own data

The new alarm stocks were defined for the chosen material indexes which allowed warehouse shortages that appeared beforehand. At the same time, thanks to a dynamic nature of the information stock, the alarm level reflects both lead-time and seasonal variable of the demand. It guarantees the capital frozen in reserves to be at the level of actual needs in the months to come.

3. CONCLUSIONS

In conclusion it can be observed that suggested reorganization of the supply system proves to be an important step towards improving the company's stock management. It allows adjusting the stock level to variable requirements of the market, and to changes that appear inside the company. It is obvious that the proper functioning of the suggested solution requires constant market monitoring and flexible reactions to all changes that may appear, as they need to be included in the algorism. The greatest advantage of the suggested solution is its dynamic character as it ensures that the stock level is adjusted to current needs. In order to maintain this situation, periodical control of the calculations is required as well as adjusting system to the company's requirements

BIBLIOGRAPHY

[1] Bozarth C., Handfield R.B. *Wprowadzenie do zarządzania operacjami i łańcuchem dostaw* ONE Press, Helion, Gliwice 2007

[2] *Buxey G.*, Reconstructing inventory management theory, *International Journal of Operations & Production Management, Year: 2006, Vol. 26, Issue 9, p. 996-1012*

[3] Czerska J., *Metody ustalania wielkości partii dostawy*, http://www.zie.pg.gda.pl, > (15.08.2009)

[4] Mak K.L., Hung C.H. , *A Simple Model for Computing (s, S) Inventory Policies when Demand is Lumpy*, International Journal of Operations & Production Management, Year: 1986, Vol. 6, Issue 2, p. 62-68

[5] Moinzadeh K., Aggarwal P. *Analysis of a production/inventory system subject to random disruptions*, Management Science (USA), Nov 97 (43/11), Vol. 43, p. 1577-1589

[6] Skowronek C., Sarjusz – Wolski Z., *Logistyka w przedsiębiorstwie*, Polskie Wydawnictwo Ekonomiczne, Warszawa 200