

EVALUATION PROBLEM AND ASSESSMENT METHOD OF WAREHOUSE PROCESS EFFICIENCY

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Abstract

Warehouse processes are one of the key elements of material flow efficiency along the supply chain. In the literature and scientific research is difficult to find a comprehensive analysis evaluation warehouse processes efficiency. Lack of unambiguous definition makes it impossible to develop a universal method for evaluation of warehouse processes efficiency. In addition, element hampering the standardization of evaluation methods is the specificity of the warehouse processes. Warehouse processes can focus on ensuring flow continuity of the production or distribution process. These problems are condition for conducting detailed scientific research in this area.

Comprehensive analysis of efficiency requires both an operational data relating to technological process, supported by support processes and service, but also the data generated by an information system in order to ensure their reliability and timeliness. For this reason, the efficiency analysis should ultimately affect the warehouse process, taking into account both the material flow and information flow, as well as the aspects of warehouse management and existing feedback.

The main aim of researches presented in the article is improving of product profitability by value and efficiency enhancement of warehouse processes according to score of multi-criteria analysis (MCA) encompassing cost-efficiency and cost-effectiveness analysis – CE|EA or cost benefit analysis – CBA among other. Authors have made attempts of indicators compilation to assess the warehouse processes efficiency, including basic assumptions of Balanced Scorecard.

Key words: warehouse efficiency, warehouse process, logistics controlling

1. INTRODUCTION

The specificity of warehouse processes will need to concentrate on those factors that have a crucial impact on the continuity of the material flow throughout the supply

chain. The scientific studies of the logistics management, can be found a lot of factors - the processes and resources - that affect the whole warehouse process. It is therefore clear that the warehouse management should focus on ways to improve the efficiency of processes, both internal and external supply chain and continuous monitoring and evaluation of the results. The research problem identified by the Authors during the research literature and observations in enterprises have assessed the efficiency of warehouse process, taking into account the multi-dimensional analysis of the interrelationships within the process, as well as linkages with other processes affecting the continuity of material flow.

In economic aspect efficiency is the result of company's activity, which is a proportion of the achieved effect to borne spending:

$$E = \frac{e}{s} \quad (1)$$

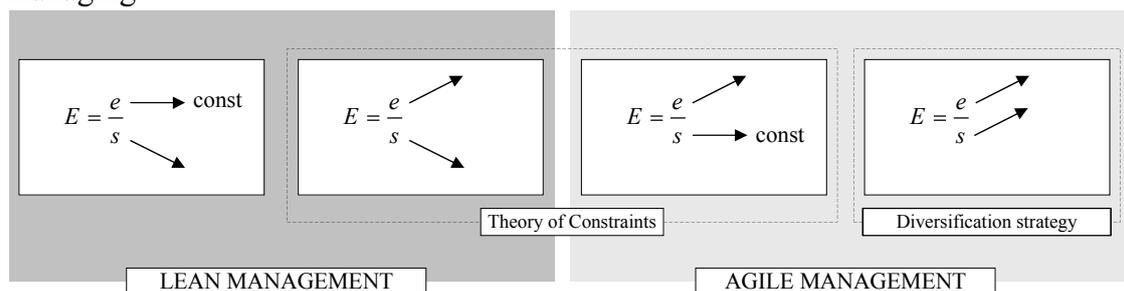
key: E- efficiency; e – effects; s – spending

Complexity of warehouse management is supported by a number of managing concepts which are implemented in order to improve warehouse efficiency. According to model (1) we can distinguish few methods of improving efficiency of actions:

- lowering spendings and keeping the level of effects at the same time,
- lowering spendings and raising the level of effects at the same time,
- keeping the level of spendings and raising the level of effects at the same time,
- raising the level of spendings and raising drastically the level of effects at the same time.

Figure 1 shows basic methods of improving warehouse efficiency and attributing them to chosen concepts of managing.

Figure 1. Attributing methods of improving efficiency to chosen concepts of managing



Source: own study based on (Kolinski, 2013)

The basis of the above picture is conviction that Lean Management concept concentrates on lowering spendings by, among others, lowering the level of expenses. Agile Management concept, on the other hand, does not focus on expenses optimisation. Therefore, the methods of improving efficiency which did not concern lowering spendings were recognised as characteristic of Agile Management concept. Theory of Constraints concentrates on two methods of improving efficiency: improving effects and keeping spendings as well as improving process and lowering

spendings (e.g. reducing the supply of work in progress). According to the definition of diversification (Kolinski, 2010), raising effects is possible thanks to increasing spendings (e.g. introducing new products or entering new markets).

Literature analysis only confirms the complexity of warehouse efficiency. Most organizations say they are continually trying to increase their productivity. There are really four ways of doing this (Waters, 2002):

- improve effectiveness with better decisions,
- improve efficiency using fewer inputs to achieve the same outputs,
- improve performance in some other way such as higher quality, fewer accidents, less disruption,
- improve morale to give more co-operation and incentives.
- Nevertheless, it needs to be remembered that aiming at maximising efficiency can entail numerous threats. The most dangerous traps of maximising efficiency are:
 - lack of coordination in realisation of operational aims of individual departments with strategic aims of a company or a supply chain,
 - discrepancy between strategic aims formulated by individual companies which are elements of a supply chain,
 - discrepancy between operational aims of different departments of a company.

2. SPECIFIC OF WAREHOUSE PROCESS EFFICIENCY

Warehouse management is a very important element of business activity of each enterprises. Therefore, warehouse management in the enterprise is of particular importance. Warehouse management shall be examined at least in three key areas of processes jointly influenced in supply chain (Sürrie & Reuter, 2015):

- procurement - the aim of warehouse management is to receive materials and raw materials for the production of suppliers, storage and issuing to production,
- production - where the task of warehouse management is reduced to an optimal allocation of materials and resources to the appropriate areas and production stages,
- distribution - where to store, completed and deliver finished goods in such a way as to meet the expectations of customers (right product, at the right time, the right place, at the right price).

Warehouse efficiency is a concept which is quite difficult to define. Generally efficiency can be defined as a measurement (usually expressed as a percentage) of the actual output to the standard output expected. Efficiency measures how well something is performing relative to existing standards; in contrast, productivity measures output relative to a specific input, e.g., tons/labor hour. Efficiency is the ratio of (APICS, 2004):

- actual units produced to the standard rate of production expected in a time period,
- standard hours produced to actual hours worked (taking longer means less efficiency),

- actual volume of output in value to a standard volume in a time period in value.

Analyzing the warehouse process in terms of efficiency, determine the objectives and tasks of effective warehouse management, which is shown in Table 1.

Table 1. Objectives and tasks of effective warehouse management

Objectives	Tasks
maximize use of storage space, achieved through appropriate measures in the design, construction and commissioning of the magazine and responding to current changes;	ensuring the availability of technical and personal resources to achieve the planned level of activity - only possible with close coordination with the leadership of the company;
	ensuring the flow of goods corresponding to the requirements for deliveries and shipments - requires cooperation warehouse with procurement and sales departments;
minimizing the use of manipulating operations - the first step eliminates redundant operations, and the second seeks to reduce the execution time of necessary activities	Solid planning, control and maintaining the use of all available resources - is made at the operational level and can be based on production schedules and orders placed with suppliers or sales plans and orders from customers;
	continuous monitoring, evaluation and improvement of the warehouse process according to established criteria - should be based on selected indicators and gauges reflecting the process

Source: own study based on (Niemczyk, 2010, p. 248-251)

Admitting the validity of the thesis that warehouse management has a significant impact on the functioning of the company, it is clear it should strive to continuously improve the functioning of the warehouse. The most important factors affecting the increase of functioning productivity of the warehouse, are:

- adjustment of flow into warehouse capacity - the starting point should be to determine the warehouse capacity. Based on it, working with the businesses, it should set a schedule for deliveries and shipments to avoid the accumulation of work during the day and excess loading units flowing through the warehouse,
- the use of storage space - refers to the efficient management of the available amount of storage area,
- rationalization of routes traveled by employees and the goods - this factor is most important for the process of completion, except that you should strive to eliminate or shorten the routes traveled by employees without the goods,
- use of staff - analyzing this factor should be paid attention to three criteria: load-time employees, they possess the competence and stability of employment,

- effective information flow - has a key impact on the implementation of all phases of the warehouse process. Any disruption in the flow of information (especially in the stage of completion and issuance) may result in delays in the implementation of contracts.

Besides organizational factors outlined above, the efficiency of warehouse processes also depend on the following factors:

- modern equipment of warehouse,
- the use of modern technology,
- utilization of automatic identification systems based on barcodes or a system of EPC / RFID,
- the use of information systems supporting warehouse management (WMS).

In its detailed analysis of the warehouse process in terms of operational controlling, should be evaluated (Śliwczyński, 2011a, p. 139):

- the efficiency of warehouse resources and their utilization,
- performance and reliability of warehouse operations,
- load handling time of the adoption until the release and warehouse capacity, taking into account downtime, queues and bottlenecks in the flow of goods.

Warehouse efficiency is a very important issue from the point of view of processes organised in a company and in a supply chain. Improving the efficiency of a warehouse process is therefore a very important factor in controlling actions. The efficiency analysis process applies the techniques of Value Stream Mapping on the value stream product of warehouse processes chain. Product value analysis for n values making up a set of dependent variables is multifunctional in its nature. A set of values W_n at the end of the supply chain depends on the results of component operations D_k in the warehouse operations chain (utilizing space, equipment, and labor effectively), e.g. timeliness and completeness of warehouse operations, warehousing quality and reliability, exact order picking and handling (ICRC, 2004, p. 285-362).

$$W_{n=1}^N(n) = f \left[D_{k=1}^K(k) \right] \quad (2)$$

It should be noted, however, that despite numerous references to science literature, in practice economic efficiency analysis is not applied so as to provide successful support decision processes occurring in the enterprise. Scientific research performed by the Authors in identifying difficulties in carrying out a comprehensive analysis of the efficiency of processes confirms low level of analytical tools use in business practice (Kolińska & Koliński, 2013, p. 2-6). It should be noted that 46% of surveyed enterprises did not perform such analyze or is not aware of this. Despite the fact that 54% of enterprises use efficiency analysis process, it shall be regarded as unsatisfactory and confirming the generally prevailing opinion that the efficiency analysis is a complex process and difficult to use in practice, especially due to the lack of universal analytical tools to support its implementation. However, results also indicate an increase in awareness of the need for efficiency analysis in order to improve the competitive position on the market.

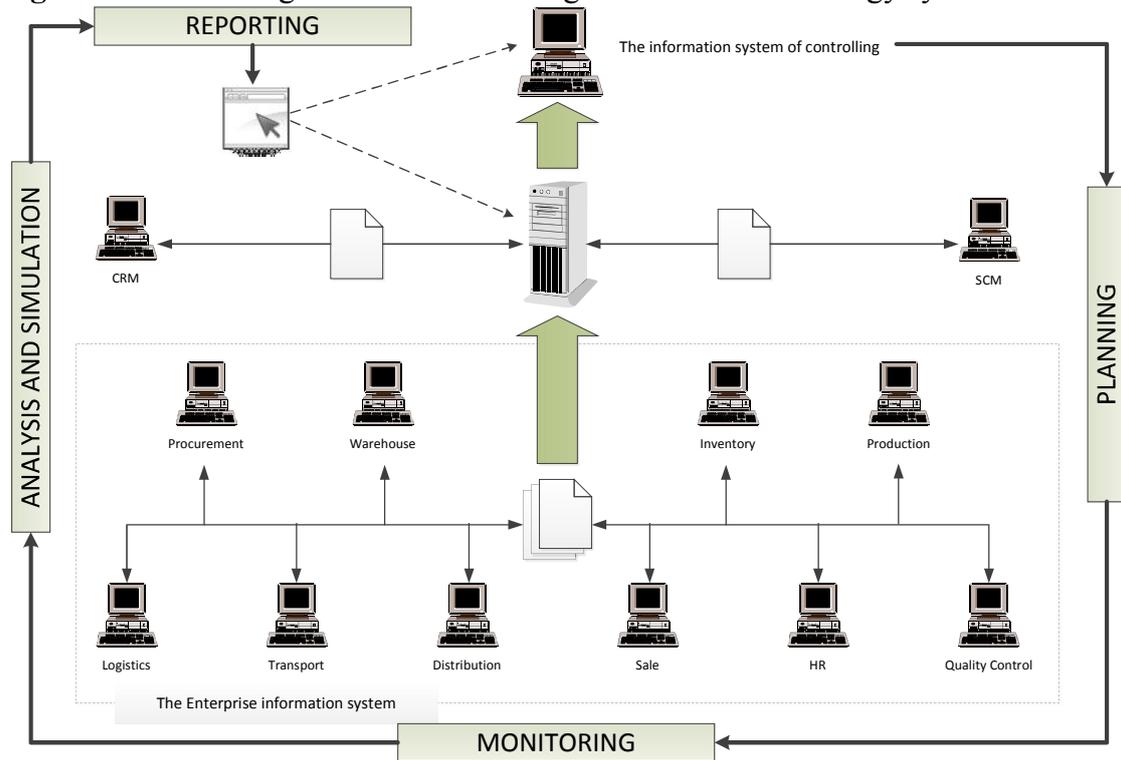
3. IT SUPPORT OF WAREHOUSE EFFICIENCY ANALYSIS

The main role of information technology tools is to support gaining, processing and distributing data, which makes the process of making decisions by the management more efficient. Nowadays, a very competitive factor is the information flow time, which shortens processes in enterprise. It is also a very important aspect of management actions concerning the analysis and assessment of warehouse process efficiency as the time of making strategic and operational decisions relies on these actions. Continuous time pressure makes it difficult to analyse data and draw the right conclusions (Kolinski & Sliwczynski, 2014, p. 206). Therefore, it seems to be vital to implement IT solutions in analytical tasks not only in a warehouse process but also in a process in company and supply chain. The main task of IT tools supporting efficiency assessment is to assist managers in a process of enterprise's management. Controlling IT systems have been undervalued and their implementation and practical use have been very scarce and general. Nowadays, IT tools for supporting the assessment of warehouse processes efficiency are taking on a special meaning, especially for companies oriented on gaining a competitive dominance on the market.

These are mainly large and medium logistics companies which generate the biggest demand for collecting, processing and storing data with the help of IT tools supporting decision making. Due to fragmentation and diversity of this sector we can distinguish three stages for IT support of warehouse process efficiency:

- carrying out efficiency analyses based on spreadsheet programs,
- implementation of analytical tools in an environment of ERP class integrated systems for managing enterprise,
- developing dedicated IT systems to specific of warehouse processes and related with other elements of material flow in a supply chain.

Controlling in a warehouse processes which is supported by a computer should take into account specific requirements of all information recipients. Information technology system of controlling takes the information necessary to carry out analyses from a data warehouse, where all the transactional data recorded in a company is saved. This transactional data contains: data concerning customer service (CRM), data for managing a supply chain (SCM), data concerning supply, warehouse, inventory, production, logistics, transport and shipping, distribution, finance and accountancy, sales, HR and payroll, and quality control. Combining all received information with the help of a controlling information technology system makes it possible to carry out cross-sectional analyses of a company's activity. The functioning rules of an independent controlling information technology system are presented in figure 2.

Figure 2. Functioning rules of a controlling information technology system

Source: own study (Fajfer et al., 2014, p. 43)

The main tasks of an independent controlling information technology system are planning (operational as well as constructive-financial), monitoring, analysis and simulations as well as reporting. The functionality of an independent controlling information technology system is compared to the functionality of a controlling module included in ERP class information technology system. Nevertheless, the independent system is much more detailed than the system of ERP class. For this reason it can not only single-handedly supervise all controlling processes in a company but also serve as a tool supporting the work of an integrated information technology system. The controlling system makes it possible to use one, integrated database which contains all current and archival information generated by all processes taking place in a company. The information obtained from a controlling system enable:

- improvement in operational and constructive-financial planning (budgeting),
- precise monitoring of logistics' plans realisation and their diversion from reality,
- state analysis and signaling a threat with the help of index analysis,
- plan and budget correction,
- reaction to diversions from a plan or a budget,
- carrying out analyses and forecasts of investments, projects and results,
- compilation of results of budget realisation analysis,
- reporting,

- determining the tools for analysis and control, which should be used in a company's economic activity so as to increase its competitiveness on the market.

Using information technology tools of controlling entails many benefits for efficiency in a company and a supply chain. The most important benefits are (Fajfer et al., 2014, p. 44):

- quick access to managerial information,
- obtaining more detailed analyses and, in consequence, obtaining better bases for making decisions,
- possibility to carry out data analyses single-handedly,
- monitoring planned task realisation from the area of logistics,
- possibility to make a simulation of the influence which made decisions have on a whole company's result,
- possibility to carry out a comprehensive analysis and forecast of a company's logistics functioning.

4. INDICATORS FOR ASSESSING WAREHOUSE EFFICIENCY

An analysis of warehouse efficiency should be based not only on operational indicators, which are directly connected with warehouse process, but also on financial indicators. Aims and indicators used in an analysis of warehouse efficiency should result from a company's vision and strategy. An analysis of warehouse efficiency can be named complete when it does not only refer to indicators which apply to past results but also when it allows to monitor what affects future results. The problem of complete warehouse efficiency assessment has still not been polished in the matter subject literature. Taking into account ecological aspect, the problem of warehouse efficiency assessment can be based on the assumptions of Balanced Scorecard developed by R. Kaplan and D. Norton. The authors proposed the analysis of efficiency from four perspectives: financial, customer, internal business process, and learning and growth. Many companies already have performance measurement systems that incorporate financial and nonfinancial measures. What is new about a call for a "balanced" set of measures? While virtually all organizations do indeed have financial and nonfinancial measures, many use their nonfinancial measures for local improvements, at their front-line and customer facing operations. Aggregate financial measures are used by senior managers as if these measures could summarize adequately the results of operations performed by their lower and mid-level employees. These organizations are using their financial and nonfinancial performance measures only for tactical feedback and control of warehouse process in short-term (Kaplan & Norton, 1996, p. 8).

No.	name of indicator	formul a	characteristic	unit
2.	Return on equity (ROE)	$\frac{a}{b}$	a - net income after tax	%
			b - shareholder equity	
3.	Return on assets (ROA)		a - net income	%
			b - mode of total assets	
4.	Return on sales (ROS)		a - net profit	%
			b- sales revenue	
5.	Ratio of material inventory turnover		a - material consumption costs	%
			b - average stocks of materials	
6.	Ratio of worker productivity	a - net sales	%	
		b - salary costs		
* Investment, means the money which were spend for buying things which will be sold (Goldratt & Cox, 2004).				

Source: own study based on (Kolinski, 2013)

The table shows only chosen financial indicators which, in author’s opinion, are most often used when assessing warehouse efficiency. There are many more indicators which can be useful in economic practice but it needs to be borne in mind that the more indicators, the bigger the threat of missing the main aim of carrying out an analysis.

Table 3 presents chosen indicators of assessing efficiency in a customer’s perspective.

Table 3. Chosen indicators of assessing efficiency of warehouse processes in a customer’s perspective

No.	name of indicator	Formula	Characteristic	unit
1.	Effectiveness of realization of orders	$\frac{a}{b}$	a - number of completed orders	%
			b - total number of orders	
2.	Quantity or value market share		a - volume of the customers target group	%
			b - total market volume	
3.	Average duration of material receipt		a - lead time of material receipt	h
			b - number of material receipt	
4.	Share of defective material receipt to customer		a - number of defective material receipt	%
			b - total number of material receipt	

Source: own study based on (Kolinski, 2013)

Indicators in the customer perspective should be considered as key factors for process improvement initiatives across the organization. Planning orientation and organizational integration resulted in process optimization across the supply chain resulting in a higher service level with reduction in inventories (Sehgal et al., 2006). Table 4 presents chosen indicators of warehouse process efficiency in a perspective of an internal process.

Table 4. Chosen indicators of warehouse process efficiency in a perspective of an internal process

No.	name of indicator	Formula	Characteristic	unit
1.	The indicator of warehousemen productivity	$\frac{a}{b}$	a - the rotation of inventory	%
			b - the average number of employees in the warehouse	
2.	Warehouse capacity utilization		a - used warehouse capacity	%
			b - total warehouse capacity	
3.	The indicator of average stock rotation		a - the rotation of inventory	%
			b - number of days in the period	
4.	Duration of the warehouse orders for assortment groups	a - overall duration of orders	h	
		b - number of orders		

Source: own study

Encapsulation of efficiency in warehouse process is best apparent in collation of indicators from internal business process perspective. This state of things should not be surprising as these are processes which take place on an operational level that have the biggest contribution in assessing warehouse process efficiency.

Table 5 presents chosen indicators of warehouse process efficiency in learning and growth perspective.

Table 5. Chosen indicators of warehouse process efficiency in learning and growth perspective

No.	name of indicator	Formula	Characteristic	unit
1.	Ratio of material inventory turnover	$\frac{a}{b}$	a - material consumption costs	%
			b - average stocks of materials	
2.	Flexibility of warehouse process		a - number of executed special orders	%
			b - total number of special orders	
3.	The indicator of warehousemen productivity		a - the rotation of inventory	%
			b - the average number of employees in the warehouse	

4.	Share of defective material receipt to customer	a - number of defective material receipt	%
		b - total number of material receipt	

Source: own study

Indicators of warehouse process efficiency in learning and growth perspective are the most wanted form of assessing warehouse process efficiency. However, they are also the most difficult to develop. One needs to remember that indicators of development also entail different threats. The indicators can be inconsistent with the basic strategic aims. When preparing a collation of indicators for warehouse process efficiency assessment one needs to bear in mind the link between individual perspectives. Analysing and compiling indicators of efficiency assessment for each perspective individually can lead to the situation which is reverse to the one expected. We can then get a set of indicators which exclude one another.

5. CONCLUSION

Warehouse process is one of the key processes affecting the value-added in supply chain. This is due to the fundamental objective of the warehouse, which is to enable the availability of assortment in a specific quantity, a specific place and a specific time. The problem of warehouse process efficiency, which was presented in this article refers only to economic aspects. It should be remembered that the assessment of efficiency should also include technical and organizational aspects.

Problem of comprehensive efficiency analysis applies not only to process warehouse. Authors within the framework of research activities analyze the impact of individual phases of material flow on the supply chain efficiency. The authors of the current research analyzed the problems of evaluation of production efficiency (Kolinski, 2012; Kolinski, 2013; Kolinski et al., 2014) and procurement process (Sliwczynski & Kolinski, 2012a; Sliwczynski & Kolinski, 2012b). The aim of further research is to standardize a method of evaluation of supply chain efficiency in economic aspect, by the analogous to develop a indicators system for transport and distribution processes, generally based on assumptions of the Balanced Scorecard.

The issues of the efficiency are widely discussed in the scientific literature, but there is still lack of a comprehensive method, which enables the multivariate analysis and the estimation of supply chain. When building a model for the evaluation of the efficiency, the correlation of all levels of business management should be taken into consideration. The ecological aspect of supply chain, gaining lately the special attention, should be also considered. The implementation of IT systems, supporting the management process, is a practical problem related to the process of building the supply chain efficiency model. The functionalities of such supporting systems enable to obtain and analyze all aspects necessary to fulfil a comprehensive analysis. Therefore, it seems to be reasonable, to prepare a separate IT tool, which will focus on a comprehensive efficiency analysis of all processes in the supply chain and which should be considered as the future direction of researches in this area.

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