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SUPPLY CHAIN MANAGEMENT BASED ON LOGISTIC AND STATICAL INDICATORS

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ABSTRACT. Background: Article presents a model concept of supporting supply chain management based on predefined correlation between logistic and statistical performance indicators. Paper presents how, set of logistics indicators at different levels of management and a set of statistical indicators broken down by macroeconomic and microeconomic level, can be used in order to improve supply chain management. The correlation coefficients are presented for evaluating the relationships between the selected samples of individual indicators.
Methods: In order to present relationships between the indicators used are elements of statistics such as correlation coefficients Spearman's rho and Kendall's tau-b.
Results: As a result of work carried out obtained a list of logistics indicators and statistics that can be used when making decisions in supply chain management. Obtained the degree of relationships between the individual indicators, through the designation values of correlation indicators.
Conclusions: Efficient supply chain management requires not only the proper selection of indicators, both logistical and statistical, which support decision-making. Important element is also identification of the correlation between the indicators at micro (company) and macro (environment) level. This will enable the correct way to draw conclusions from the reports and take corrective action for a specific branch or a company.

Key words: indicators of logistics and statistics, coefficient of correlation.

INTRODUCTION

The European economy has been experiencing some radical changes in the last few years. The analysis of the data of the European Statistical Office shows a 5% increase in the sales and turnover in wholesale and retail trade in European Union states. Companies have been adjusting their strategies to the changing market conditions. Merges of companies take place, new process management concepts are introduced. At the same time, competition gets stiffer and consumers' expectations grow. It should be also noted that regardless of the economic growth rate, the transportation of goods by road increased in the last four years. As an example, on the basis of the latest data made available by the European Statistical Office (Eurostat), the share of road transportation in goods shipping in Europe was 79% in total inland freight tonne-km.

These changes forced companies who not only wish to survive, but also to develop and bring the expected profits, to introduce changes to their operation and supply chain management. The challenge lies in the complexity of the relations between the activities performed by the companies and the environment where they are active. For example the more frequent deliveries to the clients the higher traffic on the road appears. Such traffic can cause delays in delivery time, so finally can reduce

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the efficiency and effectiveness of the delivery process. Thus, identification of real correlation between logistics and statistical indicators is a must once the company wants to consciously manage their supply chain.

Companies usually have a twofold attitude towards indicators that enables them to measure efficiency and effectiveness of their activities. On the one hand, there are companies that try to measure as many elements and areas in particular processes as possible and react to changing indicators and standards whenever they come up while, on the other hand, some companies end their analysis on the financial stage.

Objectively, both approaches have their advantages and disadvantages. The most effective solution would be to work out such a set of indicators that would suit an individual company's needs. The choice of suitable indicators which support making decisions at individual stages of management is a vital element which has an influence on the efficiency of the actions taken and on the shape of a company's policy.

Analyses carried out by the Institute of Logistics and Warehousing show that the indicators used by a company should include customers' needs and deal with efficiency as well as be coherent with a company's strategy.

The subject matter literature defines efficiency as a characteristic which can be ascribed to every action and which defines the achievement level of set actions' results, which generally cater for needs and enable achieving goals and coming up to one's expectations. Efficiency is also a non-economic term which characterises an action intended to achieve a set result. Efficiency needs a comparison of the effects with the costs incurred to achieve the set results [Lichocik, Sadowski, 2013]. It also means effective economic action which can be defined by the relation between achieved effects and the cost incurred to achieve these effects. There is a cause and effect relation between the cost input and the effects.

An additionally important element in a management process is setting current values of individual indicators, defining the target (normative) value of these indicators as well as the targets for which individual indicators are measured. The aforementioned information should be handed over to particular departments or the people responsible for a given indicator so that they would be aware of their duties in this area. A good practice is also a cyclic analysis of the values of individual indicators and setting possible repairing actions which should improve the present situation and aim at the target value of a given indicator.

Nevertheless, it should be remembered that measurement only of logistic indicators will not give the same opportunities as combining them with statistical indicators. Setting a correlation indicator between individual indicators (logistics and statistical) can give much adequate results for drawing correct conclusions on each of management stages.

The aim of the article is to present an example approach how managers can define set of logistic and statistical indicators standards for different stages of management. The article also shows connections between individual indicators. As a result an article shows analyses to what extent the decisions concerning supply chains can be supported by identification of strong relations between different indicators and its further constant measurement.

LOGISTIC INDICATORS ESSENTIAL FOR DECISION MAKERS ON PARTICULAR MANAGEMENT STAGES

The subject matter literature gives different divisions of indicators and standards according to a particular criterion. A detailed analysis can reveal a division of indicators and standards according to:

- the data they are connected to- quantitative/ qualitative,
- the element of the process it concerns- input, output

– the stage of the management at which they are used- operational, tactical, strategic.

The present article focuses on the indicators classified according to the management level at which decisions are made. The management level consists of three main parts [Heizer, Render, 2008]:

– operation,
– tactical,
– strategic.

Operations management is the set of activities that creates value ih the form of goods and services by trans forming inputs into outputs. Activities creating goods and services take place in all organizations. In manufacturing firms, the production activities that create goods and usually qualite obvious parts [Heizer, Render, 2008].

Table 1. A list of chosen logistic indicators used at particular management stages
Tabela 1. Lista wybranych wskaźników logistycznych używanych na poszczególnych poziomach zarządzania

No.	Name of indicator and measure	Level of management		
		operation	tactical	strategic
1	Stock coverage rate	X		X
2	The share not rotating stock in total stock	X		
3	Indicator exceeded the planned lead time	X		
4	Accuracy of sales forecast	X		
5	Fill-factor vehicles	X		
6	Technical readiness indicator of transport fleet	X		
7	Utilization indicator of car mileage	X		
8	Indicator of timeliness of carriage	X	X	X
9	Indicator cargo of damage during transport	X	X	
10	Share of transport costs in total costs of enterprises	X	X	X
11	Indicator of exploitation of warehouse (in terms of quantity and value)	X		
12	Indicator of surface inventory management (in terms of quantity and value)	X		
13	Indicator of cubature inventory management	X		
14	Indicator of performance warehouse	X	X	X
15	Indicator of warehousing costs in relation to value of stocks			X
16	Indicator of warehousing costs in relation to value of stocks	X	X	X
17	Cost of completing a single order	X		
18	Indicator timely deliveries by suppliers [%]	X	X	X
19	Indicator timely deliveries to customers [%]	X	X	X
20	indicator of level of execution of orders [%]	X	X	X
21	Level indicator complaints from suppliers [%]	X		
22	Level indicator complaints from customers [%]	X	X	X
23	Number of tonnes transported freight	X	X	X
24	Number of car accidents in enterprise	X	X	X
25	Expenses on R&D			X
26	Greenhouse gas emissions			X
27	Customer Satisfaction	X	X	X
28	Transport costs	X	X	X
29	Labour costs		X	
30	Level of noise emission			X
31	Level of waste			X
32	Level of recycling of products			X
33	Emission level of CO2 from transport processes			X
34	Level of leakage of harmful substances			X

Source: own study based on Sergeev, 2005, Heizer, Render, 2008

The administrative process of selecting among appropriate ways and means of achieving a strategic plan or objective is understood as tactical management. The use of tactical management in a business environment allows a manager to choose the best tactics or methods for each situation that arises, rather than following a particular standard procedure [Reda, Lederking, 2004].

Finally, strategic management is the process and approach of specifying an organization's objectives, developing policies and plans. In other words, strategic management can be seen as a combination of strategy formulation, implementation and evaluation [Raduan, Jegak, 2009].

Dividing level of management into three parts is caused by the necessity to differentiate between the level of detail and the area of influence of particular indicators.

Table 1 shows a list of chosen logistic indicators which can be used by companies to support making decision on different management stages.

STATISTICAL INDICATORS AND STANDARDS SUPPORTING MAKING DECISIONS IN A COMPANY

Eurostat as well as statistical agencies in given countries (e.g. The Main Statistical Office in Poland) publishes statistical data on a microeconomic level as well as on a macroeconomic level which describes basic tendencies of a social-economic development.

Table 2. A list of statistical indicators and standards supporting making decisions in a company
Tabela 2. Lista wskaźników statystycznych i standardów wspomagających podejmowanie decyzji w przedsiębiorstwach

No.	Name of indicator and measure	Source of data about indicator	Level	
			macroeconomic	microeconomic
1	Traffic intensity on the roads (vehicles/h)	GDDKiA		X
2	Average trip length by purpose (km) for the different modes of transport	GUS		X
3	Number of tons of cargo for transport modes	GUS, Eurostat		X
4	Degree of congestion for individual transport modes	GDDKiA		X
5	Transport broken down into modes of transport (tkm)	GUS, Eurostat		X
6	Quality of environment (noice level and pollution from modes of transport)	GUS, Eurostat		X
7	Number of accidents / year	The Main Police Station database		X
8	Gross Domestic Product (GDP)	GUS	X	
9	Average monthly gross nominal wage in the corporate sector (Enterprises, in which the number of employees exceeds 9 persons) (in zł)	GUS	X	
10	Price indicator of consumer goods and services	GUS	X	
11	International Trade (import / eksport)	GUS	X	
12	Industrial Production	GUS	X	
13	Retail sales of selected foods	GUS		X
14	Number of flats for which building permits were issued and construction started	GUS		X
15	Employment rate	GUS, Eurostat		X
16	Gross domestic expenditure on R&D	Eurostat	X	
17	Greenhouse gas emissions	Eurostat	X	
18	Primary energy consumption	Eurostat	X	

In the case of The Main Statistical Office in Poland (GUS), the data on the macroeconomic level is presented according to types of business defined by the Polish Business Classification 2007. Other institutions which can be a potential source of data concerning indicators are the following: (in case of Poland) The Main National Roads and Motorways Management (GGDKiA) and The Main Police Station.

The choice of accurate indicators and standards depends on individual company as well as on the type of decisions which making should be supported by particular indicators. Table 2 presents statistical indicators and standards which support making decisions in companies in different sectors and branches.

Individual indicators and standards can be used to support making decisions at different management stages as well as for benchmarking [Fertsch, 2008], in order to determine where a company is located in comparison to other companies in a given country.

CORRELATION BETWEEN LOGISTIC AND STATISTICAL INDICATORS

An important aspect of an analysis of logistic processes efficiency is intentional formulation of a set of indicators which make it possible to avoid contradictory results. Thus, an essential element of developing the set of indicators is their correlation with statistical indicators. Statistical indicators predispose developing a correlation between variables in the form of, for example, a function which enables shaping the analysed logistic processes and, consequently, supporting decision making of a company's management board.

The measurement of correlation between two variables which are randomly dependent can be carried out with the use of a few measures. Most often used measurements of the power of variables correlation are the following [Wang, Xie, Chena, Yang J., Yang M., 2013, Monjardet, 1998]:

Czuprow coefficient of convergence

The indicator of the convergence can have values in the <0,1> bracket. It can be used to measure measurable as well as immeasurable correlations. The smaller the real power of the correlation of measured variables, the lower the number value of the indicator (it aims at 0). The disadvantage of this ratio is lack of presenting the direction of the measured variables.

Pearson coefficient of correlation

This indicator takes the values from the <0, 1> brackets not showing the direction of the correlation. The advantage of this measure is the possibility of using it not only in the case of linear correlation but also in the case of askew linear correlation.

Pearson linear coefficient of correlation

The measure takes the values from the <-1, 1> brackets showing the direction of the correlation. The suggestion for the interpretation of the indicator has been shown in a table. The disadvantage of this measure is the possibility of using it to measure the power of variables interdependence only in the case of linear correlation as well as the possibility to measure both variables.

Table 3. Interpretaion of the linear coefficient of correlation
Tabela 3. Interpretacja liniowego współczynnika korelacji

Value of the coefficient		**Interpretation**
0 – (- 0,3)	0 – 0,3	No correlation or very poor correlation
-0,3 – (- 0,5)	0,3 – 0,5	Moderate correlation
-0,5 – (- 0,7)	0,5 – 0,7	Strong correlation
- 0,7 – (- 1)	0,7 – 1	Very strong correlation

Source: Ścibor-Rylski, 2007

Spearman Rank Correlation

This indicator is used to measure rank correlation of two variables and it takes the vales from the <-1, 1> brackets showing

the direction of the correlation. In the case when the measure equals 0 it reflects variables independence, while -1 or 1 shows dependence between the variables. This indicator is used in the case when there is an ordinal scale.

Kendall Rank Correlation

This measure is used in the case of an ordinal scale and it takes the values from the <-1, 1> brackets showing the direction of the correlation.

Depending on the data, an appropriate correlation indicator should be chosen thanks to which it will be possible to determine the interdependence between measured variables.

Presenting the relation between chosen indicators is possible in two ways. On the one hand, we can set a correlation indicator between individual indicators and standards. On the other hand, we can determine the dependence of indicators based on our knowledge and experience.

Table 4. Matrix of correlation between indicators and measures that assess mezo, micro and macro scale
Tabela 4. Macierz korelacji pomiędzy wskaźnikami, które są wykorzystywane w scali mezo, makro i mikro

Mezo and macro scale / Micro scale	Region / Country							
	Traffic intensity on the road (vehicles / h)	Average trip length by purpose (km) for the different transport branches	Number of tons of cargo in branches of transport	Degree of congestion for individual transport branches	Transport performance divided into branches of transport (tkm)	Quality of the environment	Number of accidents	Number of cooperating companies
Transport costs								X
Share of transport costs in value of the exported foods								X
Maximum value of discount on the price of product resulting from the new organization of transport processes								X
Structure of shipments	X	X		X	X	X		X
Average duration of delivery		X		X				X
Correct of order (Prawidłowe zamówienie)								X
Degree of use of means of transport				X	X	X		X
Degree of use of working time of means of transport				X	X	X		X
Share of each mode of transport in carriage of foods	X	X	X	X	X	X	X	X

Source: own study

In the first case we need to know the values of the individual indicators in order to determine the correlation indicator. In the other case numerical data is not necessary. Nevertheless, this solution has an important disadvantage. It is the fact that the information about indicators dependence is determined on the basis of one person's subjective opinion.

The table 4 presents a correlation matrix between given logistic indicators and standards as well as statistical indicators assessing the micro, mezon and macro scale.

Due to a great number of presented indicators and standards it would be difficult to show all set correlation indicators in the present article. Therefore, the table presents

only Spearman Rank Correlation and Kendall Rank Correlation for a few exemplary indicators.

The data for each indicator has been collected from the questionnaires carried out among companies (109 companies) from Poland and other European or world countries. Half of the companies taking part in the questionnaires are companies employing up to 100 people. The questionnaire used an ordinal five-level scale. Therefore, the factors that could have been set for individual indicators were the Spearman Rank Correlation and Kendall Rank Correlation.

The aformentioned types of factors were set using the SPSS Statistics tool. Table 5 presents list of indicators with the highest correlation coefficient identified during the survey.

Table 5. Correlation coefficients of Spearman's rho and tau-b Kendall's for selected indicators
Tabela 5. Współczynnik korelacji Rho Spearmana i tau-b Kendalla dla wybranych wskaźników

Indicator 1	Indicator 2	Correlation					
		rho Spearmana			tau-b Kendalla		
		Correlation coefficient	Significance (both sides)	N	Correlation coefficient	Significance (both sides)	N
Customer satisfaction	Transport costs	0,287**	0,004	100	0,256**	0,004	100
Customer satisfaction	Labour costs	0,285**	0,004	101	0,263**	0,003	101
Customer satisfaction	Level of waste	0,302**	0,007	79	0,266**	0,008	79
Customer satisfaction	Level of recycling products	0,248*	0,032	75	0,214*	0,035	75
Customer satisfaction	Emission level of CO2 from transport processes	0,291*	0,018	66	0,258*	0,018	66
Transport costs	Labour costs	0,534**	0,000	102	0,503**	0,000	102
Transport costs	Emission level of CO2 from transport processes	0,306*	0,013	66	0,268*	0,011	66
Emission level of CO2 from transport processes	Labour costs	0,297*	0,015	66	0,257*	0,016	66
Emission level of CO2 from transport processes	Level of noise emission	0,527**	0,001	53	0,509**	0,001	53
Emission level of CO2 from transport processes	Level of waste	0,577**	0,000	61	0,521**	0,000	61
* Correlation is significant at the 0.05 level (both sides)							
** Correlation is significant at the 0.01 level (both sides)							

Source: own study

When analysing the aforementioned results, it can be seen that, according to the surveyed sample, there are three pairs of indicators between which there is a strong correlation:

- the level of CO2 emission coming from transport processes- the level of waste,
- the level of CO2 emission coming from transport processes- the level of noise emission,
- transport costs- labour costs.

When it comes to other indicators, the dependence is on a very low level. The closer the value of a correlation indicator to zero, the lower the level of the dependence.

SHAPING THE SALES POLICY OF A COMPANY

A suitably developed sales policy of a company is a vital element of a proper functioning of the whole company. We should also remember about verification of sales policy and taking into account in that process a number of variables which influence a company's shape, such as, for example,

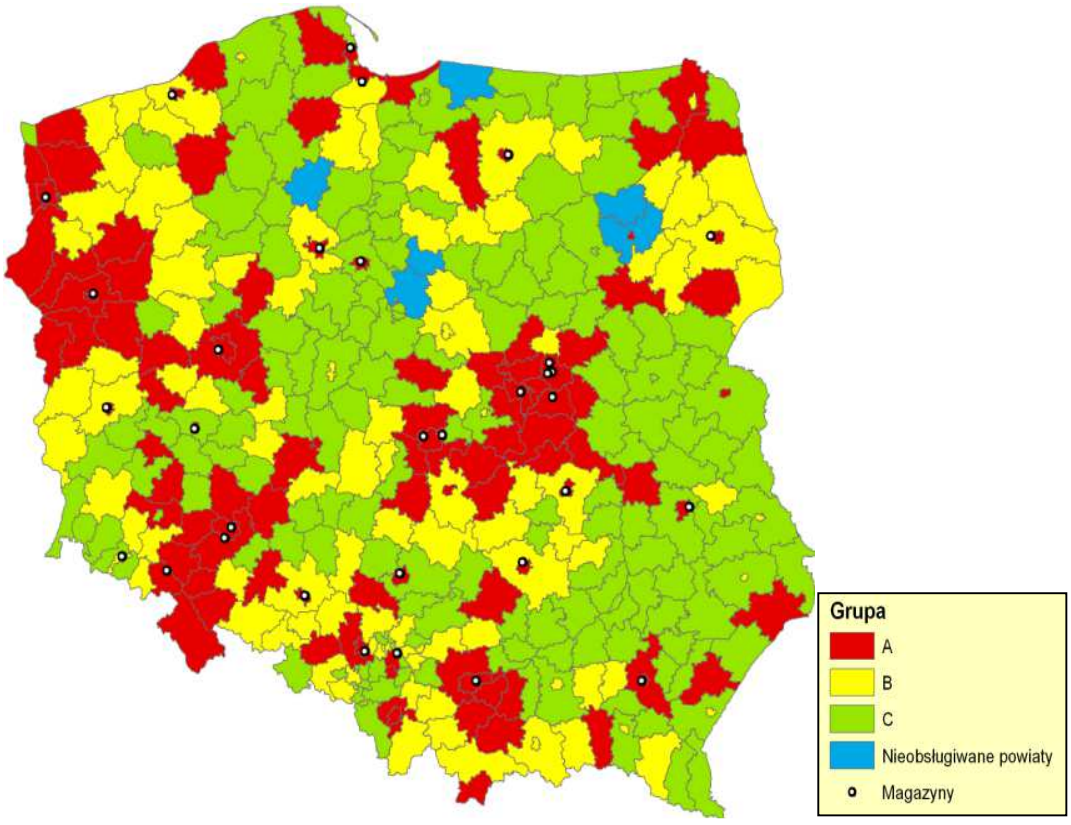
the indicators and standards presented in the chapters of this article. It is also essential to analyse the indicators with the high level of correlation, as the actions taken to improve one element will also affect another element of the process.

In the previous years companies have aimed at eliminating or at least limiting the influence of individual's salesman characteristics in order to improve the sales and the process efficiency. Nowadays this attitude has been changing. Therefore, when shaping the sales policy such elements as sales management control system and sales territory design are analysed as moderators and/or determinants of performance of salespeople and effectiveness of sales organizations [Babakus, 1996].

When shaping a company's sales policy, it is worthwhile to take into consideration the data in micro and macro scale which considerably affect a company's appointed policy.

An exemplary process of supervision and verification of sales policy can include the following elements:

- monthly meetings of a sales manager with the trade team,
- weekly reports monitoring a sales budget,
- monthly meetings of Sales Department,
- competitors' analysis- on the basis of the information included in companies' balance sheets,
- monitoring the changes in the prices of products which are on a company's offer,
- an analysis of reports concerning the markets on which a company functions.



Source: own study

Fig. 1. The division of districts on ABC group by value of sales
Rys. 1. Podział powiatów na grupy ABC wg wartości sprzedaży

Such a wide range of analysed data enables companies to manage a sales process fast and effectively. It also helps to react quickly to a changing situation on the market.

It is also advisable to use the ABC analysis (Pareto analysis) according to a sales' value in order to present counties which generate the highest and the lowest income for the analysed company. Therefore, it is possible to determine an accurate allocation of new warehouses or the need to carry out a detailed analysis concerning the workload of the warehouses which serve the counties classified as group A.

CONCLUSION

Nowadays every manager has to make a number of decisions on a daily basis. The decision can be connected with an operational, tactical or strategic level. Making decisions on different levels of management requires support from different logistic as well as statistical indicators and standards [Hernández, García, Hernández, 2013]. As every manager makes his/her decisions based on different set of indicators. They can be very wide, depends on the company profile, but need to take into consideration correlation between logistics and their impact to the environment where the company is active.

Another important aspect which should be taken into account when choosing a particular set of indicators is determining the dependence between individual indicators on the basis of statistical calculations. In this way we can avoid inappropriate conclusions and, consequently, making wrong decisions.

It is possible to determine a correlation indicator between many indicators without using an appropriate tool. However, it is very time- consuming and requires lots of calculations. An example of a tool which helps to calculate the correlation ratio is the SPSS by IBM.

Another vital element necessary for determining the correlation indicator is having the values for individual indicators and standards between which we are to set the level of dependence. Lack of such data results in only one possibility, that of determining the dependence between the indicators based on knowledge and experience.

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ZARZĄDZANIE ŁAŃCUCHEM DOSTAW W OPRARCIU O WSKAŹNIKI LOGISTYCZNE I STATYSTYCZNE

STRESZCZENIE. **Wstęp:** Artykuł prezentuje modelową koncepcję wspierającą zarządzanie łańcuchem dostaw w oparciu o zidentyfikowane korelacje pomiędzy wskaźnikami opisującymi procesy logistyczne oraz procesy makroekonomiczne w regionie, w którym dana firma działa. Artykuł prezentuje przykładowy zestaw wskaźników logistycznych na poszczególnych poziomach zarządzania oraz zestaw wskaźników statystycznych w podziale na poziom makroekonomiczny i mikroekonomiczny, które mogą zostać wykorzystane w usprawnieniu zarządzania łańcuchem dostaw. Dodatkowo przedstawione zostały współczynniki korelacji służące do oceny powiązań pomiędzy poszczególnymi wskaźnikami.
Metody: W celu przedstawienia relacji pomiędzy poszczególnymi wskaźnikami zastosowane zostały elementy statystyki tj. współczynniki korelacji Rho Spearmana i tau-b Kendalla.
Wyniki: W wyniku przeprowadzonych prac uzyskano zestaw wskaźników logistycznych jak i statystycznych, które mogą być wykorzystane podczas podejmowania decyzji w obszarze zarządzania łańcuchem dostaw. Uzyskano również stopień powiązań poszczególnych wskaźników pomiędzy sobą wyznaczając wartości wskaźników korelacji.
Wnioski: Racjonalne zarządzanie łańcuchem dostaw wymaga nie tylko odpowiedniego doboru wskaźników zarówno logistycznych jak i statystycznych wspomagających podejmowania decyzji. Istotnym elementem jest również zidentyfikowanie korelacji pomiędzy poszczególnymi wskaźnikami, aby w poprawny sposób wyciągać wnioski z raportów i podejmować działania naprawcze.

Słowa kluczowe: wskaźniki logistyczne, wskaźniki statystyczne, współczynnik korelacji Rho Spearmana i tau-b Kendalla

MANAGEMENT DER LIEFERKETTE IN ANLEHNUNG AN LOGISTISCHE UND STATISTISCHE KENNZIFFERN

ZUSAMMENFASSUNG. Einleitung: Der Artikel präsentiert ein modellhaftes Konzept, das das Management der Lieferkette in Anlehnung an die ermittelten Zusammenhänge zwischen den die logistischen und die makroökonomischen Prozesse beschreibenden Kennziffern unterstützt. Die ermittelten Prozesse und Zusammenhänge gelten für die Region, in der die analysierte Firma tätig ist. Der Beitrag stellt einen beispielhaften Satz von logistischen Kennziffern auf den einzelnen Management-Ebenen sowie den Satz von statistischen Kennziffern auf dem makro- und mikroökonomischen Niveau dar, für die Vervollkommnung des Managements der Lieferkette in Anspruch genommen werden können. Darüber hinaus wurden die Koeffizienten der Zusammenhänge, die zur Beurteilung von Verbindungen zwischen den einzelnen Kennziffern dienen, präsentiert.
Methoden: Zwecks der Projizierung der Zusammenhänge zwischen den einzelnen Kennziffern wurden die Elemente der Statistik, d.h. Koeffizienten der Korrelation von Rho Spearman und tau-b Kendall in Anspruch genommen.
Ergebnisse: Infolge der durchgeführten Arbeiten hat man einen Satz von logistischen und statistischen Kennziffern, die von Entscheidungsträgern im Management der Lieferkette angewendet werden können, ermittelt. Man stellte dabei den Grad der gemeinsamen Zusammenhänge zwischen den einzelnen Kennziffern fest, indem man die Werte für die Kennziffern der betreffenden Korrelation erfasste

Fazit: Das rationelle Management innerhalb einer Lieferkette bedarf nicht nur einer entsprechenden Auswahl sowohl logistischer als auch statistischer Kennziffern, die das Entscheidungstreffen unterstützen. Das wesentliche Element ist auch die Ermittlung der Korrelation zwischen den einzelnen Kennziffern zwecks einer richtigen Schlussfolgerung in Bezug auf die Berichterstattungen vor Ort und der Inangriffnahme von Verbesserungsvorhaben..

Codewörter: logistische Kennziffern, statistische Kennziffern, Koeffizient der Korrelation von Rho Spearman und tau-b Kendall

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