

TRUST OR DOUBT: ACCURACY OF DETERMINING FACTORS FOR SUPPLY CHAIN PERFORMANCE

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Abstract: The aim of the research is to determine the accuracy of defining factors for supply chain performance. The most used factors in the literature are: sharing information, responding to challenges, cooperation among members, relationships, and trust. The method of the study is meta-analysis. Our results suggest that the effect of the examined factors on the performance is not complete, and the inclusion of other factors in later studies is indispensable because the results obtained indicate the presence of unknown influencing factors. The effect of the examined factors in the whole population is likely to be positive, but weak or moderate.

Key words: supply chain performance, meta-analysis, trust, cooperation, information sharing, environmental challenges

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Introduction

Successful enterprises are connected with many business partners. The prerequisite of the efficient operations of a business is to form a long run and continuous relationship with the partners, forming a supply chain. To know the efficiency of a supply chain it is essential to measure its performance. Many factors have been examined to evaluate the performance of supply chains. Financial, non-financial and logistical performance indicators were identified as supply chain performance factor groups. These factors can be influenced by a number of other things, such as trust between partners, shared information, and coordinated work in different areas (Oláh et al, 2017a; Oláh et al., 2017b; Klietk et al., 2018).

The purpose of the research is to determine the factors that influence supply chain performance, using the method of meta-analysis. These factors are the most frequently used indicators found in the relevant, selected publications. The effect of the selected factors on the supply chain performance is measured by correlation analysis.

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In the first phase of the study, it will be described in detail how the various factors are interpreted in the studies involved. The factors studied are the relationship and trust between the partners, the sharing of information required, and the answers to the factors of effectiveness and environmental challenges that are essential to the world today. After presenting the factors examined and how the authors of the studies think about the individual factors, the meta-analysis methods used in my study will be presented. Since many of these methods exist, we use three methods that are designed to examine correlation coefficients. These methods are Hunter and Schmidt's method, and Hedges and Olkin's, as well as fixed and random models suggested by Rosenthal and Rubin indirectly using correlation coefficients because correlation coefficients should be converted to Fisher's z values. These methods will also be shown. As the coefficients are more fragmented in some articles, it is also necessary to demonstrate the method of computing the multiple correlation coefficients. The method of calculating partial correlation is presented and used to better understand the generation of performance. This can best be done by excluding the effect of the other factors on the relationship between the factor and the performance, the partial correlation coefficient being used. In the literature review, the scope and the range of meta-analysis will also be presented to make it easier to understand this tool.

During the analysis, the main factors will be discussed in the following order. First, we describe the tests on unfiltered correlation coefficients, firstly the results of the Hunter and Schmidt methods, and then the results of the randomized meta-analysis method of fixed and/or transformed randomized meta-analysis. The partial correlation analysis is also done in this order.

In the study we assume a strong positive correlation relationship between all the selected factors and supply chain performance. Thus, the relationship, trust, cooperation, information sharing, and factors of response to environmental challenges are believed to have a strong positive impact on the supply chains' performance.

Literature Review

The measurements of supply chain performance can be done to apply logistical performance indicators to supply chains. Supply chain performance is influenced by a number of factors; the most frequently used in the literature are relationships, trust, cooperation, information sharing and response to environmental challenges.

The *relationships* in the chain can be used to make certain changes to the company, for example, introducing a modern IT technology or enhancing innovation (Gunasekaran et al., 2017; Huo et al., 2015), but can also be used to increase trust (Kim et al., 2011; Mandal et al., 2017). After a while, the cooperative relationship becomes natural, so it can be said that relations deepen over time (Sroka and Hittmar, 2013; Ryoo and Kim, 2015; Felföldi, 2011). In some cases, the relationship cannot be separated from the assessment of the chain's performance since the relationship is an element of the evaluation (Kim et al., 2011).

Relationships appear in common decisions that are necessary to achieve common goals (Mishra et al., 2016). Relationships help maintain and expand fruitful business co-operation (Kumar et al., 2017; Kovacova et al., 2018). Close links enhance chain security (Wu et al., 2014), which motivates actors to participate in supply chain deployment and maintenance). Because of the advantages of the relationships, the partners are motivated for the cooperation (Ryoo and Kim, 2015). Relationships are influenced by trust and dependence, and dependence promotes reaching the desired goal.

Trust is an abstract concept (Singh and Teng, 2016), so it is difficult to measure its level. One definition of trust is the expectation of common beliefs and the corresponding events. Trust is one of the most important areas in maintaining relationships (Panayides and Lun, 2009; Sroka, 2011). Trust in the supply chain is important because if partners trust each other they share information (Ryoo-Kim, 2015; Oláh et al., 2018). One dimension of trust can be the sharing of information among the chain actors, the other dimension being the mutual understanding in pairs. Because trust is closely related to the relationship, it reduces costs and conflicts (Chen et al., 2013).

Implementation of the lean approach, acceptance, and supply chain agility are a way to strengthen trust among the supply chain members. Trust is an informal co-operation and management policy for companies to maintain their market position. Trust also appears in innovation (Panayides and Lun, 2009), focussing on innovation and the innovative partners of the supply chain.

Cooperation includes many areas such as management co-operation (Eng, 2006, Mandal et al., 2017), or cross-functional co-, this also applies when marketing strategies are coordinated (Green et al., 2012). A less institutional co-operation when the corporate cultures of supply chain members are embedded. Process integration is also a form of cooperation (Wang et al., 2014; Vörösmarty and Dobos, 2019).

As cooperation between companies has to take into account the interests of many companies, it provides a more comprehensive picture of the supply chain environment (Wang et al., 2014; Meyer et al., 2016; Meyer and Meyer, 2017). Sharing information can create an atmosphere that is a kind of cultural expression that will make the company and the supply chain open and transparent (Wei et al., 2012, Felföldi and Szöllösi, 2011). Cooperation contributes to the reduction of conflicts and costs while increasing the efficiency of corporate cooperation.

Information sharing facilitates the flow of information in the supply chain (Mandal et al., 2017) that assists the material stream. To facilitate information sharing, advanced IT tools are also used, and reliable and relevant data should be used for reliable relationships (Zhou and Benton, 2007). The most frequently transmitted information comes from technical, financial, operational and strategic areas. As a result of the information sharing, chain members can make joint decisions (Dong et al., 2016; Singh-Teng, 2016). Operational information sharing can affect the efficiency of operations such as service standards (Zhou and Benton, 2007).

Sharing of information has a positive effect on the co-operation (Wu et al., 2014) as a result; information sharing has similar advantages such as reduced costs (Lai et al., 2008) and reduced numbers of conflicts (Wei et al., 2012). Sharing knowledge is a key success factor, and this finding is recognized by more and more companies (Chen et al., 2013), therefore these enterprises increase the number of joint developments and consider transparency as a key factor. Through knowledge sharing, members exchange their knowledge of the market, including demand for products and market.

The *response to environmental challenges* in logistics can be interpreted as a new approach. To accept innovation requires an inclusive culture and trust that is accessible through relationships (Um et al., 2017; Ghobakhloo and Azar, 2018). Innovation and environmental insecurity must be linked with dynamic adaptation. Adaptation requires two important factors: to obtain the right information and to change the roles within the supply chain. There is environmental uncertainty due to lack of information, market fluctuations and technical developments (Yang, 2014). As a result, as uncertainty is increasing, the exchange of information ought to be improved in the supply chain (Lee et al., 2014). Supply chains are more responsive to environmental uncertainty as they are able to exchange information and take coordinated action against it. Strategic flexibility is defined as a quick response to environmental uncertainties, but requires good management practice and organizational response capability (Arnold et al., 2015).

Meta-analysis synthesizes and summarizes publications in a particular research area. Researchers can have a wider and more accurate knowledge in the field of science as they create a huge sample base that cannot be found in any research. However the meta-analysis may deter the researcher from the proper conclusions as the studies involved in the meta-analysis are not accurate. Not just the inaccuracy of publications can deter the MA, but the small number of publications can do the same. In case of not having appropriate number of publications conduction of an independent own research should be considered. The first MA was conducted in psychology, and has since been used in many studies (Papp, 2015). Hunter and Schmidt (2004) applied MA in finance research, however there are also publications using this method in logistics and supply chain management (e.g.: Ataseven and Nair, 2017; Bhosale and Kant, 2016).

Research Hypotheses

The most important factors in the literature and performance correlation indices are included in the analysis. Our hypotheses are as follows:

H1: The more efficient the sharing of information, the greater the supply chain's performance, so a strong positive correlation between these two indicators is assumed.

H2: The better prepared the supply chain to the changing environment, the better the performance. A strong positive correlation relationship is assumed.

H3: The most challenging in the supply chain management is to work together for success, so a strong positive correlation is expected between collaboration and performance.

H4: The deeper the relationships, the more reliable the supply chain members, and thus the greater their performance, and the whole chain's performance is greater. Here, too, there is a strong positive correlation relationship.

H5: The higher the trust, the better the members can cooperate, and the better the common performance. So here is assumed a positive correlation assumption.

H6: The three former factors affecting the supply chain in H3, H4 and H5 are closely related, so their correlation coefficients are likely to be close to each other.

Materials and Methods

Relevant studies were selected from the ScienceDirect database from 2000 to 2018. The publications were found in the following journals: Computers in Human Behavior, Expert Systems with Applications, IFAC Proceedings Volumes, Industrial Marketing Management, Information & Management, International Journal of Accounting Information Systems, International Journal of Information Management, International Journal of Production Economics, Journal of Business Research, Journal of Operations Management, Omega, Procedia Manufacturing, European Journal of Operational Research, Journal of Business Logistics, Journal of Manufacturing Technology Management, and International Journal of Disaster Resilience in the Built Environment.

The articles were selected from the ScienceDirect database; the terms searched were correlation and supply chain performance. Five of the most important factors that influenced supply chain performance were characterized by relationships, trust, cooperation, information sharing and response to environmental challenges.

As a result of the selection, 33 studies were involved in the analysis. The requirements for selected articles were to include the correlation matrix and the five factors mentioned above. The Rosenthal Fail-Safe Number measures the meta-analysis quality was used to verify the accuracy of the analysis (Field and Gillett, 2010).

The steps of the meta-analysis were applied according to Field and Gillett (2010). Firstly, the relationships between the most important dimensions are introduced and then, using correlation coefficients, the correlation index of the whole population is calculated (Hunter and Schmidt, 2004; Field and Gillett, 2010). Then homogeneity is measured after that the fixed and random model indicators are calculated using the methods of Hedges and Olkin (1985), and Rosenthal and Rubin (1982). The final step is to measure the goodness of the test, which is the reliability of the meta-analysis. Findings can only be deduced from the published articles, but there may be tests that have not published and may contain data that may contradict our results. It is therefore necessary to examine how far the published studies can refute the results obtained

Results and Discussion

According to the method proposed by Hunter and Schmidt, the unfiltered correlation coefficients show weak medium and medium correlations between the different test criteria with the supply chain performance. Responses to environmental challenges show the closest connection to performance, while relationship management has the least close impact (Table 1-5).

Our research must first focus attention on responses to environmental challenges, but be taken in consideration of the other factors under investigation. This statement is fortified by the fact that the difference between the smallest and biggest correlation coefficients is 0.15. On the other hand the other researched factors can help to give efficient answers for the environmental challenges. The interplay of the factors under investigation would be a good topic for further research in order to better understand the supply chain's performance. From the supply chain performance variance, responses to environmental challenges represent 19%, while relationships account only for 8%.

Table 1. Correlations between relationship and SC performance

Study	Number of samples	r	partial r	Fisher's z (r)	Fisher's partial r
Gunasekaran et al., 2017	205	-0,13	-0,054	-0,130	-0,054
Yang, 2014	137	0,3	0,086	0,309	0,086
Lee et al., 2014	124	0,17	0,071	0,171	0,071
Dong et al., 2016	141	0,119	0,305	0,119	0,315
Kim et al., 2011	102	0,500	0,285	0,550	0,293
Huo et al., 2015	617	0,414	0,212	0,441	0,216
Singh-Teng, 2016	167	0,48	0,187	0,522	0,190
Wu et al., 2014	177	0,162	0,092	0,163	0,093
Mishra et al., 2016	184	0,04	0,024	0,040	0,024
Ryoo-Kim, 2015	140	0,075	0,122	0,075	0,123
Rajaguru -Matanda, 2013	302	0,524	0,346	0,581	0,361
Luo et al., 2013	117	0,448	0,369	0,482	0,387
Ellinger, 2000	309	0,266	0,099	0,272	0,099

Based on the applied fixed effect model, unfiltered correlation coefficients show a weak medium to moderate relationships. Here, similar results and suggestions can be made, than when Hunter and Schmidt's model was applied, but here the coefficients are slightly larger. So responses to environmental challenges are the most important for performance, while relationships are the least. Here it is a bit bigger difference which is 0.16. Factors in this test method explain better the variance of supply chain performance because the answer to environmental challenges explains almost 21% of variance while the relationship is almost 9%.

Table 2. Correlations between trust and SC performance

Study	Number of samples	r	partial r	Fisher's z (r)	Fisher's partial r
Eng, 2006	179	0,253	0,234	0,259	0,239
Panayides-Lun, 2009	193	0,46	0,308	0,497	0,318
Lee et al., 2014	124	0,17	0,068	0,171	0,068
Chen et al., 2013	117	0,360	0,229	0,377	0,234
Singh-Teng, 2016	167	0,65	0,437	0,775	0,468
Wei et al., 2012	154	0,492	0,348	0,539	0,363
Wu et al., 2014	177	0,112	0,091	0,112	0,091
Mishra et al., 2016	184	0,2	0,168	0,202	0,170
Ryoo-Kim, 2015	140	0,58	0,486	0,662	0,531

In the random effect model, the unfiltered correlation coefficients also indicate a weak medium to moderate relationship between the factors investigated and the supply chain performance. Similarly to the previous two approaches, the answers to the environmental challenges and the relationship factors are the two extremes. So the findings and suggestions are similar to the ones above. The biggest difference is here, which is almost 0.2. Responses to environmental challenges account for almost 22% of the variance while the relationships account for more than 7% of the variance.

Table 3. Correlations between cooperation and SC performance

Study	Number of samples	r	partial r	Fisher's z (r)	Fisher's partial r
Gunasekaran et al., 2017	205	-0,1	-0,009	-0,100	-0,009
Eng, 2006	179	0,383	0,279	0,403	0,2876
Green et al., 2012	117	0,614	0,477	0,715	0,519
Yang, 2014	137	0,02	-0,094	0,020	-0,095
Lee et al., 2014	124	0,19	-0,003	0,192	-0,003
Rexhausen et al., 2012	116	0,21	-0,083	0,213	-0,083
Chen et al., 2013	117	0,576	0,219	0,656	0,223
Wang et al., 2014	250	0,511	0,340	0,564	0,354
Huo et al., 2015	617	0,378	0,163	0,398	0,165
Lin et al, 2010	84	0,517	0,429	0,572	0,459
Wei et al., 2012	154	0,502	0,229	0,552	0,233
Wu et al., 2014	177	0,517	0,400	0,573	0,424
Kumar et al., 2017	60	0,784	0,080	1,055	0,080
Daugherty et al.,2011	125	0,296	0,120	0,305	0,120
Mandal et al., 2017	339	0,128	0,043	0,129	0,044
Roh et al., 2014	559	0,286	0,147	0,294	0,148
Ellinger, 2000	309	0,25	0,071	0,255	0,071

Yang et al., 2009	123	0,654	0,247	0,782	0,253
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Only according to Hunter and Schmidt's model it is not excluded that the correlation coefficient between relationship and cooperation is zero, relative to performance. Therefore, we need to look more closely at whether these two factors have an impact on performance to find more accurate results after the test. However, it is unlikely that these factors would be zero because the results of the other two tests exclude this.

Partial correlation coefficients show weak or poor medium direct relationships between the factors and supply chain performance based on all three test methods. Based on all three tests, from the partial correlation coefficients the greatest factor is the response to environmental challenges, as it is in the unfiltered case. So the suggestion that we have to pay the biggest attention to this factor in order to increase performance is valid, even when we filter out the effect of all the other factors from the correlation relationship.

Table 4. Correlations between information sharing and SC performance

Study	Number of samples	r	partial r	Fisher's z (r)	Fisher's partial r
Gunasekaran et al., 2017	205	-0,04	-0,016	-0,040	-0,016
Eng, 2006	179	0,446	0,395	0,479	0,418
Yang, 2014	137	0,408	0,194	0,433	0,196
Lee et al., 2014	124	0,35	0,255	0,365	0,261
Chen et al., 2013	117	0,554	0,364	0,624	0,381
Dong et al., 2016	141	0,41	0,299	0,435	0,309
Kim et al., 2011	102	0,597	0,556	0,688	0,628
Wang et al., 2014	250	0,36	-0,093	0,376	-0,094
Huo et al., 2015	617	0,291	0,081	0,299	0,082
Singh-Teng, 2016	167	0,553	0,118	0,623	0,118
Lin et al, 2010	84	0,4	-0,002	0,423	-0,002
Wei et al., 2012	154	0,502	0,264	0,552	0,271
Wu et al., 2014	177	0,303	0,125	0,313	0,126
Ryoo-Kim, 2015	140	0,439	0,439	0,471	0,47
Arnold et al., 2015	155	0,581	0,177	0,663	0,179
Kumar et al., 2017	60	0,873	0,396	1,345	0,419
Daugherty et al.,2011	125	0,416	0,348	0,442	0,364
Rajaguru-Matanda, 2013	302	0,626	0,387	0,734	0,408
Flynn et al., 2010	617	0,476	0,332	0,518	0,345
Mandal et al., 2017	339	0,081	0,042	0,081	0,042
Roh et al., 2014	559	0,236	0,107	0,241	0,107
Luo et al.,2013	117	0,346	0,195	0,361	0,198
Lai et al.,2008	227	0,692	0,652	0,852	0,779

Grawe et al., 2011	184	0,316	-0,065	0,327	-0,065
Zhou-Benton, 2007	125	0,773	0,641	1,028	0,761
Qrunfleh-Tarafdar, 2014	205	0,268	0,144	0,275	0,145
Wong et al., 2015	188	0,286	0,158	0,295	0,159

The smallest partial correlation coefficient for the first two tests is for the cooperation factor, while in the model that assumes the random effect, the relationship factor is the lowest only as in the unfiltered case. Although there are direct effects here, in our opinion, all the factors examined should be taken into account if we want to increase the supply chain performance, because the difference between the highest and lowest values in the Hunter and Schmidt methods is close to 0.14, and in the case of a model with a fixed effect, it is close to 0.15, and more than 0.16 for the random model. The effect of these factors on the variance of performance in response to environmental challenges is nearly 9% in Hunter and Schmidt models, it is 9.5% in the model with a fixed effect, and 11% in the random model. The ability to explain variance in the Hunter and Schmidt methods is 2.5%, in the fixed-effect model it is slightly more than 2.5%. The relationship factor explains about 3% of the variance of performance in the random model. Untested factors explain the variance of performance from 70% to 73%. Therefore, they strongly support the suggestion that other explanatory factors should be determined (Figure 1).

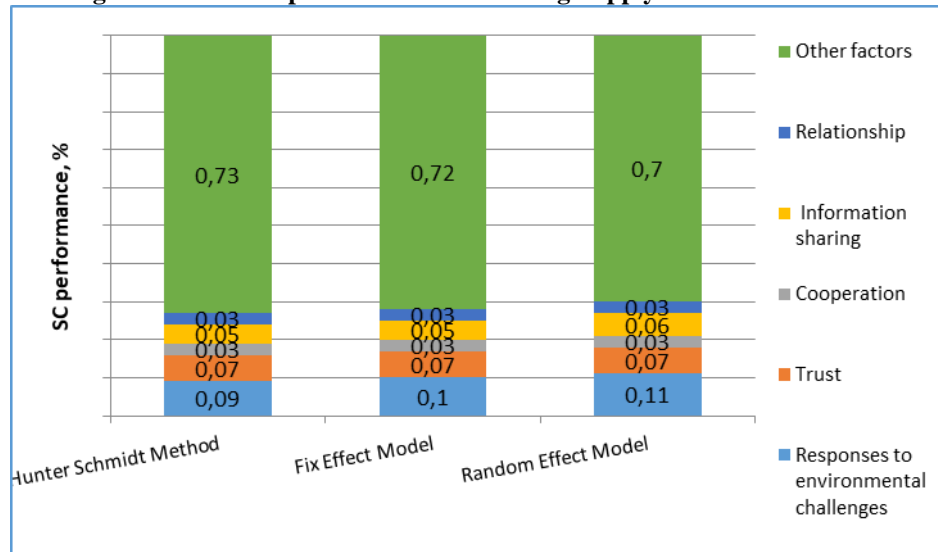
Table 5. Correlations between responses to environmental challenges and SC performance

Study	Number of samples	r	partial r	Fisher's z (r)	Fisher's partial r
Panayides-Lun, 2009	193	0,57	0,474	0,647	0,515
Yang, 2014	137	0,44	0,218	0,472	0,222
Lee et al., 2014	124	-0,07	-0,042	-0,070	-0,042
Rexhausen et al., 2012	116	0,487	0,252	0,533	0,258
Dong et al., 2016	141	0,463	0,45	0,502	0,486
Wang et al., 2014	250	0,37	0,226	0,388	0,230
Singh-Teng, 2016	167	0,34	0,050	0,354	0,050
Lin et al, 2010	84	0,503	0,377	0,553	0,397
Wei et al., 2012	154	0,110	0,140	0,110	0,140
Mishra et al., 2016	184	0,253	0,200	0,258	0,203
Arnold et al., 2015	155	0,645	0,404	0,767	0,429
Mandal et al., 2017	339	0,422	0,395	0,450	0,418
Roh et al., 2014	559	0,272	0,1431	0,279	0,144
Ghobakhloo-Azar, 2018	189	0,680	0,483	0,830	0,528
Chan et al., 2017	141	0,670	0,765	0,811	1,010
Grawe et al., 2011	184	0,715	0,571	0,897	0,649

Um et al., 2017	363	0,6144	0,2744	0,71	0,281
Wong et al., 2015	188	0,323	0,208	0,336	0,211

With the Hunter and Schmidt methods, only the trust factor has no negative and zero value in the confidence interval, although this part of the interval is very small in case of response to environmental challenges. So we would consider it important to investigate this in the future research, to see, what direction these values would take.

Figure 1. Direct Impact of Factors Affecting Supply Chain Performance



In the Hunter and Schmidt method and in the fixed effect model, heterogeneity can be observed in both unfiltered and partial cases for all factors. This is true for all or only at very small significance levels. Heterogeneity shows that the magnitude of the effects of the studies does not constitute a common population or rather there are some other existing influences that effect on the relationships of factors. A further research topic could be the discovery of these influencing factors, which may explain the remaining variance to performance.

The Fail-Safe Number for each test indicates that the test results are valid. It is only worthwhile to consider the results of further research in order to promote the above-mentioned better understanding.

Comparing our results with the analysed and discussed studies the following statements can be stated about the examined variables. All articles except Guneseakaran et al. (2017) are in line with the result of the relationship variable. At the cooperation variable all publications but Guneseakaran et al., 2017 and Kumar et al. (2017) is contained similar outcomes. At the trust, the studies came to similar

conclusion. In responses to environment challenges with the exception of Lee et al. (2014) each article was similar to our result.

Conclusions

It can be concluded that if a company wants to increase the efficiency of its supply chain management, the most important to focus on environmental challenges. Responses to environmental challenges are the most important SC performance influencers, while relationships are the least, however there are only small differences amongst the effects of the factors.

As a result of the analysis we suggest three recommendations. First, the interaction of the examined factors would be a good topic for further research to better apprehend the dynamics of supply chain performance. Second, all the five factors examined most intensively in the literature should be taken into account to increase the supply chain performance. Third, together, the analysed factors define the supply chain performance by about 30%, so 70% of the supply chain is determined by other factors, which means that there is great potential for further research.

Limitation: Since only bare-bone analysis has been performed, the result may be subject to systematic and non-systematic statistical errors other than the sampling error. For example, in some studies, more or less data could change accidentally, during data processing. Moreover applying other methods to filter out other errors can help this problem in further researches.

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ZAUFANIE LUB WĄTPLIWOŚĆ: DOKŁADNOŚĆ USTALANIA CZYNNIKÓW DLA WYDAJNOŚCI ŁAŃCUCHA DOSTAW

Streszczenie: Celem badań jest określenie dokładności definiowania czynników dla wydajności łańcucha dostaw. Najczęściej używane czynniki w literaturze to: dzielenie się informacjami, reagowanie na zapytania, współpraca między członkami, relacje i zaufanie.

Metodą badania jest metaanaliza. Rezultaty studium sugerują, że wpływ badanych czynników na wydajność nie jest kompletny, a włączenie innych czynników do późniejszych badań jest niezbędne, ponieważ uzyskane wyniki wskazują na obecność nieznanych czynników wpływających. Wpływ badanych czynników na całą populację będzie prawdopodobnie pozytywny, ale słaby lub umiarkowany.

Słowa kluczowe: wydajność łańcucha dostaw, metaanaliza, zaufanie, współpraca, wymiana informacji, wyzwania środowiskowe

信任或疑虑：确定供应链绩效的因素的准确性

摘要：研究的目的是确定供应链绩效定义因素的准确性。

文献中最常用的因素是：共享信息，应对挑战，成员之间的合作，关系和信任。

研究方法是荟萃分析。

我们的研究表明，所检查的因素对表现的影响尚不完整，在后期研究中纳入其他因素是必不可少的，因为所得结果表明存在未知的影响因素。

检查因素对整个人群的影响可能是积极的，但是弱或中等。

关键：供应链绩效，荟萃分析，信任，合作，信息共享，环境挑战