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LOGISTICS PERFORMANCE AND MANAGEMENT OF LOGISTICS SYSTEM SAFETY

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Abstract: The safety of a logistics system is understood as ensuring (to a certain level) the implementation of operational logistics processes in any entity, under specific conditions, by using favourable circumstances, taking business challenges, reducing risk, uncertainty and preventing all kinds of threats to logistics activities.
The relevant determinant of the management of logistics system safety is appropriate infrastructure which enables the implementation of logistic processes and guarantees their effectiveness and efficiency. The infrastructure determines logistics performance measured by the logistics performance index (LPI). The aim of the article is to identify the logistics system safety measures in a macro approach and to determine the impact of logistic efficiency on the management of logistics system safety.
Keywords: logistics safety, management of logistics system safety, logistics performance, logistics infrastructure

1. INTRODUCTION

The functioning of every system should be considered in the context of its safety. Safety assessment is important because it allows to identify the potential risks in complex systems and to maintain their reliable operation at acceptable costs (Li et al., 2019). What is more, risk analysis is considered a common approach to ensuring sustainability of systems (Athar et al., 2019; Guillén-Cuevas et al., 2018; Jilcha and Kitaw, 2017). When it comes to entities and business networks, safety refers primarily to ensuring the continuity of the processes they carry out. For this reason, the safety of a logistics system should be understood as a condition that guarantees the flow of tangible goods and services to meet the needs of the participants of the supply chain in accordance with the „7R" rule (right product, right quantity, right condition, right place, right time, right customer, right price), enables the flow of information for the planning and management of logistics processes, ensures protection and survival in dangerous situations (threats), and helps adapt to new conditions (Szymonik, 2016). The level of safety of a logistics system will therefore be shaped through management, i.e. the development and implementation of a set of coordinated activities directed at logistic resources that will counteract threats to the safety of the system's functioning (Szymonik, 2016). Safety management helps to correctly shape the organizations' safety decision-making processes (Wang et al., 2019; Huang et al., 2018), which is why it has become a frequent research topic regarding new directions of business management (Li and Guldenmund, 2018; Álvarez-Santos et al., 2018). Safety management of a logistics system can therefore be defined as a set of actions aimed at achieving an assumed safety status. These activities should focus on a quick response to environment changes and on cooperation with other entities. The significance of these activities results directly from the threats to the functioning of logistics systems which are intrinsic to the area of the market where the given system is active. Those threats include (Książkiewicz and Mierkiewicz, 2012):

- lack of cooperation with external entities,
- lack of professionalism of cooperating entities,
- congestion on roads and at infrastructure node points,
- lack of adequate means of transport or their reduced availability,
- availability and technical condition of logistics infrastructure.

The measure which indirectly demonstrates the safety of a logistics system from a macroeconomic perspective is the logistics performance index (LPI), which determines the reliability of logistics of different countries (Jane and Laih, 2012). The literature often presents links between broadly understood safety and efficiency (Nahangi et al., 2019; Farid et al., 2019; Stemn et al., 2019; Ghahramani and Saminen, 2019; Pandit et al. 2019; Raineri, 2019). The index takes into account virtually all elements essential for the continuity of a logistics system functioning, which is how it determines the system's safety. The most important elements include:

- customs clearance performed by border control authorities, including customs - the effectiveness of the clearance process (speed, simplicity and predictability of formalities),
- infrastructure - the quality of trade and transport resulting from the condition of infrastructure (e.g. ports, railway lines, roads, IT),
- international shipments - easy to organize shipments at competitive prices,
- logistics competence - quality of logistics services (for example, the competence of carriers, customs agents),
- tracking & tracing – the possibility to identify and track shipments,
- on-time delivery - shipments to the target place at the designated or estimated delivery time (delivery punctuality).

From the point of view of the functioning of a logistics system, activities aimed at achieving a certain state of system safety should be cost-effective to ensure the realization of basic goals of logistics. It is therefore important to manage the safety of a logistics system correctly, which should also translate into economic results, such as: turnover, value added, business expenditure on R&D. Accordingly, the aim of the article is to determine the impact of logistics performance measured by LPI on the management of the safety of logistics systems.

2. DATA AND METHODOLOGY

The functioning of a logistics system should be both safe and efficient. Therefore, the safety management of a logistics system should be focused not only on the preservation of a specific safety level, but also on the cost-effectiveness of undertaken activities. The functioning of the logistics system depends on its ability to respond to market changes and to generate economic effects.

Therefore, the conditions for the functioning of logistics systems in enterprises operating on the European market have been analyzed. The surveyed unit, however, is the European countries because they create conditions for the development of entrepreneurship, especially in the context of logistics systems. Considering the goal of the article, it was assumed that the level of logistics safety would be measured by the performance logistics index (customs, infrastructure, international shipments, logistics quality and competence, tracking and trading, timeliness), and the effectiveness of the systems, resulting from their safety management, by gross operating rate (in %) and turnover per person employed (in thousand euro) for the transport and storage sector, because of the sector's integrating and coordinating function in the realization of logistics processes. Enterprises in this sector are considered to be the basis of the logistics industry, which plays a major role in the global business environment because time and costs are significant to the success of a supply chain (Rashidi, Cullinane, 2019). The impact of logistics efficiency factors on the effects of logistics system safety management will be determined on the basis of the regression model. Data from 2016 for the 28 European Union countries were analyzed. The data come from the Eurostat and World Bank databases.

3. RESULTS AND DISCUSSION

In order to determine the influence of logistics efficiency on the effects of safety management, the parameters of two simple regression functions were estimated. The logistics performance index was assumed for the independent variable, whereas the dependent variable in the first regression function was the turnover in the transport and storage sector (calculated per one employee), and the gross operating rate of the transport and storage sector was the dependent variable in the second regression function. Due to the nature of the relationship, both linear and power parameters of the regression function were estimated. The results are shown in tables 1 and 2.

Table 1
OLS estimation and verification results of the models for *turnover* dependent variable

<table>
<tr><td rowspan="4">Linear model</td><th>Variable</th><th>Parameter estimate</th><th>Standard error</th><th>Student’s t statistics</th><th>Significance level p</th></tr>
<tr><td>const</td><td>−264.945</td><td>105.486</td><td>−2.512</td><td>0.0186</td></tr>
<tr><td>LPI</td><td>111.872</td><td>28.9545</td><td>3.864</td><td>0.0007</td></tr>
<tr><td colspan="5">mean of dependent variable 140.0179 standard deviation of dependent variable 77.61094
residual sum of squares 103313.8 standard error of residual 63.03657
determination coefficient R^2 0.364744 adjusted R^2 0.340311
F(1, 26) 14.92838 significance level p for F test 0.000666
Log likelihood −154.7168 Akaike criterion 313.4336
Schwarz criterion 316.0980 Hannan-Quinn criterion 314.2481

Breusch-Pagan test for heteroskedasticity
Null hypothesis: the error variances are all equal. LM = 0.113595
with p value 0.736088

White test for heteroskedasticity
Null hypothesis: the error variances are all equal. LM = 1.29476
with p value 0.523416

Normality tests</td></tr>
</table>

<table>
<tr><td></td><td colspan="5">Null hypothesis: random component is normally distributed. Chi-square (2) = 12.3145 with p value 0.00211803

Non-linearity test (squares)
Null hypothesis: the relationship is linear. LM = 0.00576241
with p value 0.93949

Non-linearity test (logarithms)
Null hypothesis: the relationship is linear. LM = 0.0133764
with p value 0.907925</td></tr>
<tr><td rowspan="4">Power model after linear transformation</td><td>Variable</td><td>Parameter estimate</td><td>Standard error</td><td>Student's t statistics</td><td>Significance level p</td></tr>
<tr><td>const</td><td>0.457076</td><td>0.901275</td><td>0.5071</td><td>0.6163</td></tr>
<tr><td>Log_LPI</td><td>3.38399</td><td>0.701359</td><td>4.825</td><td><0.00001</td></tr>
<tr><td colspan="5">mean of dependent variable 4.788082 standard deviation of dependent variable 0.578337
residual sum of squares 4.764655 standard error of residual 0.428084
determination coefficient R^2 0.472399 adjusted R^2 0.452106
F(1, 26) 23.27963 significance level p for F test 0.000053
Log likelihood −14.93657 Akaike criterion 33.87313
Schwarz criterion 36.53754 Hannan-Quinn criterion 34.68767

Breusch-Pagan test for heteroskedasticity
Null hypothesis: the error variances are all equal. LM = 1.45644
with p value 0.227498

White test for heteroskedasticity
Null hypothesis: the error variances are all equal. LM = 2.09229
with p value 0.351289

Normality tests
Null hypothesis: random component is normally distributed. Chi-square (2) = 5.45536 with p value 0.0653708

Non-linearity test (squares)
Null hypothesis: the relationship is linear. LM = 0.00633995
with p value 0.936536

Non-linearity test (logarithms)
Null hypothesis: the relationship is linear. LM = 0.00732397
with p value 0.9318</td></tr>
</table>

The analysis of the estimation of the first regression function with the dependent variable Turnover shows that the linearized model is better compared to the linear model, especially when it comes to assumptions regarding the normality of residual distribution. This leads to the conclusion that the power model describes the relationship between the LPI level and turnover better. The relationship between the two variables is positive, and therefore an increase in LPI results in an increase in turnover.

Table 2
OLS estimation and verification results of the models for *gross operating rate* dependent variable

<table>
<tr><td rowspan="4">Linear model</td><th>Variable</th><th>Parameter estimate</th><th>Standard error</th><th>Student’s t statistics</th><th>Significance level p</th></tr>
<tr><td>const</td><td>21.6503</td><td>5.21475</td><td>4.152</td><td>0.0003</td></tr>
<tr><td>LPI</td><td>−2.26042</td><td>1.43138</td><td>−1.579</td><td>0.1264</td></tr>
<tr><td colspan="5">mean of dependent variable 13.46786 standard deviation of dependent variable 3.201279
residual sum of squares 252.4836 standard error of residual 3.116233
determination coefficient R^2 0.087522 adjusted R^2 0.052427
F(1, 26) 2.493840 significance level p for F test 0.126383
Log likelihood −70.51826 Akaike criterion 145.0365
Schwarz criterion 147.7009 Hannan-Quinn criterion 145.8511

Breusch-Pagan test for heteroskedasticity
Null hypothesis: the error variances are all equal. LM = 1.26026
with p value 0.261601

White test for heteroskedasticity
Null hypothesis: the error variances are all equal. LM = 1.02935
with p value 0.597696

Normality tests
Null hypothesis: random component is normally distributed. Chi-square (2) = 5.29858
with p value 0.0707014

Non-linearity test (squares)
Null hypothesis: the relationship is linear. LM = 0.187734
with p value 0.664809

Non-linearity test (logarithms)
Null hypothesis: the relationship is linear. LM = 0.140369
with p value 0.707915</td></tr>
<tr><td rowspan="4">Power model after linear transformation</td><th>Variable</th><th>Parameter estimate</th><th>Standard error</th><th>Student’s t statistics</th><th>Significance level p</th></tr>
<tr><td>const</td><td>3.43921</td><td>0.472695</td><td>7.276</td><td><0.00001</td></tr>
<tr><td>Log_LPI</td><td>−0.676242</td><td>0.367844</td><td>−1.838</td><td>0.0775</td></tr>
<tr><td colspan="5">mean of dependent variable 2.573720 standard deviation of dependent variable 0.234204
residual sum of squares 1.310626 standard error of residual 0.224519
determination coefficient R^2 0.115035 adjusted R^2 0.080998
F(1, 26) 3.379682 significance level p for F test 0.077456
Log likelihood 3.133518 Akaike criterion −2.267035
Schwarz criterion 0.397374 Hannan-Quinn criterion −1.452499

Breusch-Pagan test for heteroskedasticity
Null hypothesis: the error variances are all equal. LM = 1.62875
with p value 0. 0.201875

White test for heteroskedasticity</td></tr>
</table>

	Null hypothesis: the error variances are all equal. LM = 1.73422 with p value 0.420164 Normality tests Null hypothesis: random component is normally distributed. Chi-square (2) = 1.71473 with p value 0.424279 Non-linearity test (squares) Null hypothesis: the relationship is linear. LM = 0.318807 with p value 0.572325 Non-linearity test (logarithms) Null hypothesis: the relationship is linear. LM = 0.269911 with p value 0.603392

Also in the case of the regression function with the dependent variable Gross operating rate, the power function worked better, in particular with regard to the parameter significance at the independent variable (it is statistically significant with a significance level of 0.13 for the linear function and 0.1 for the power function after linear transformation). The relationship between the variables is negative. However, a negative relationship is not a negative phenomenon, because it results from the increase in transactions directly related to the production process.

Although the relationship between the LPI level and the effects of logistics systems safety management was observed with the use of the simple regression function, it was not observed for the separate influence of the six factors making LPI on the management of logistics systems safety. These factors, however, differentiate individual countries in terms of the functioning of logistics systems (fig. 1), and, accordingly, influence the safety of the systems and the effects of their management.

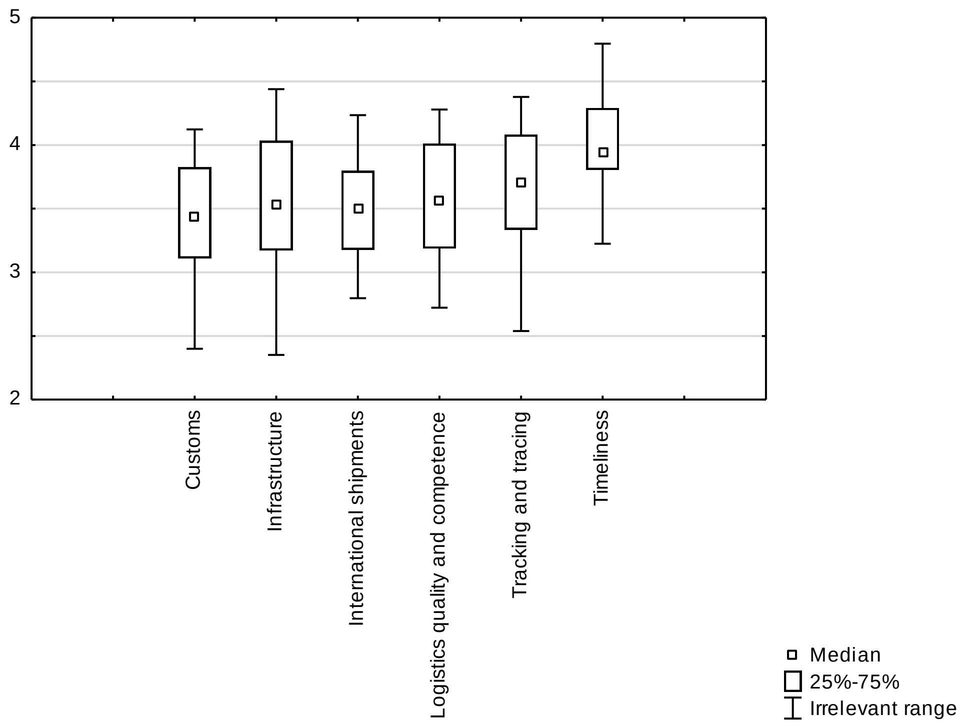

Fig. 1. Box plot of characteristics

For this reason, the next stage of research will be to build a model illustrating the impact of the six areas of logistics performance: customs, infrastructure, international shipments, logistics quality and competence, tracking and trading, timeliness on turnover and gross operating rate. The study of multiple dependencies between individual areas of logistics efficiency and the effects of safety management of logistics systems is important because each of the areas is associated with a different type of risk connected with the functioning of logistics systems.

4. CONCLUSION

Safety is an important feature of logistics systems because it ensures their efficient and effective functioning. Safety should be guaranteed first of all by the areas of logistics efficiency that determines the economic activity of enterprises. Hence logistics performance index (LPI) was assumed as the measure of logistics system safety level. It should be remembered, however, that the efficiency of logistics systems should go hand in hand with the effectiveness of their operation, which is influenced by both turnover and gross operating rate. The analysis of the relationship between the LPI level and the turnover and gross operating rate shows statistically significant relationships. The increase in the level of logistics efficiency, and thus indirectly the safety of logistics systems, has a positive effect on the turnover level and a negative effect on the gross operating rate of the transport and storage sector whose companies are important for the integration and coordination in logistics. Therefore, one can conclude that there exists an interrelationship between the safety of logistics systems and the ability to achieve their goals, especially in terms of their turnover and costs, and thereby the effectiveness of functioning.

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