Logistic process indicator (LPI) as the measure of infrastructural and regional development

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Abstract: Logistics represents a network of services that support the physical movement of goods, international trade and commerce within borders. The volume of international trade highly depends on factors facilitating trade and contributing to reducing its costs. Logistic is affecting the speed of globalization through optimizing the supply chain. Furthermore, this interdependence is the reason why the improvement of logistic is seen as an essential element of the regional and global development. The main aim of this study is to investigate the impact of key dimensions that affect the logistic process indicator (LPI) and to highlight their importance by applying the adequate methodology of its modeling. The evaluation of the LPI is performed using variables that include customs, infrastructure, ease of international shipments, logistics services quality, tracking and tracing and timeliness. Parameters have been collected for the period from 2007 to 2018. The extensive research is considering the data from 160 country in order to perceive the global level of the LPI. Outcome of the artificial neural network is used to underline developed segments of the logistic process and those segments of the process that need to be further developed.

Keywords: logistic process indicator, prediction, artificial neural network

Introduction

Having in mind that we are living and working in a very dynamic environment with strong competition and strict trade conditions, logistics processes and services are also developing fast. Logistics performance is based on reliable supply chains and predictable service delivery for traders [1]. The most reliable tools for high quality logistics today are information technology solutions and efficient management. National competitiveness depends on the ability to manage logistics in today's global business environment.

The Logistics Performance Index (LPI) is calculated based on a global survey of global freight forwarding companies and logistics carriers. It is an online benchmarking tool developed by the World Bank [2] that measures productivity across the entire supply chain of logistics within a country [3]. The World bank has recognized the significant role of national logistics performance in world trade, as well as differences between countries in logistical parameters. Therefore, since 2007 the World bank initiated an annual global survey of national logistics performance which led to the LPI index development [2]. The index can help countries identify logistic systems' problems and find opportunities to improve logistics efficiency. The World Bank conducts a survey every 2 years. The latest current rating was compiled by the World Bank in 2018 and was calculated for 160 countries. The higher the LPI value, the more developed the logistics system in the country [4].

Research focus in lots of recent studies is on investigating the competitiveness between market participants, but the main aim of this paper is to investigate the global LPI produced by the World Bank [2], to explore the correlation between LPI indicators and to measure which of the six indicators, the LPI is based on, have the biggest influence to the overall LPI score. The six key indicators are: (1) Customs - the efficiency of customs and border management clearance, (2) Infrastructure - the quality of trade and transport infrastructure, (3) ease of arranging shipments - the ease of arranging competitively priced shipments, (4) quality and competiveness of logistics services, (5) tracking and tracing as the ability to track and trace deliveries, and (6) the frequency with which shipments reach consignments within scheduled delivery times namely timeliness.

The international LPI represents an overall measure of the efficiency of the logistics sector, combining data on six key performance indicators into a single aggregated measure, so there is a need to analyze the indicators behavior, relations between them, and their impact on overall LPI score. To do this, we used Pearson's correlation and artificial neural network analysis. The results will show the prediction ability of ANN model and measure the impact each independent variable has on the overall LPI score.

This research study is organized into five sections. Section 2 is providing the insight into the recent literature review in the field of logistics development. Section 3 is

describing the data that have been evaluated and methodological approach that has been used to generate prediction model for LPI. The outcome of the implemented analysis has been presented in the section 4 along with the discussion of the most valuable findings. Section 5 is presenting the conclusion of the study.

Literature review

The field of logistics performance (LPI) is the subject of research by numerous authors. This section reviews the literature related to the logistics performance index concerning important conclusions reached in this area.

The World Economic Forum [5] uses interstate evaluation to compare logistics country performance and assess their impact on reducing supply chain barriers, and reducing tariffs in the economy.

Some studies link logistical performance fluctuation with international trade volume changes showing correlation between key logistical indicators and world trade [6]. These studies show the acceptance of the LPI as a measure of assessing the logistics performance of a country, relate logistics performance to trade, and transport policy.

Many authors are linking the LPI index with other logistics indexes such as Global competitiveness index – GCI. Çemberci et al. [7] studied the moderator effect of the Global Competitiveness Index (GCI) on the LPI and concluded that a higher score on the GCI can be achieved by improving the LPI components timeliness, tracking and tracing, and international shipments.

Authors [8] investigated the influence of LPI on the export rate in 23 Asian countries. The results of the study highlight the importance of investing in logistics infrastructure that showed the highest potential to improve the export rates.

Min and Kim [9] combined the LPI score and the Environmental Performance Index (EPI) to create the Green logistics performance index, which presented a completely different ranking than either the LPI or EPI.

Liu et al [10] explored the connection between LPI and environmental impact assessed using CO_2 emissions in Asian countries. The main findings from the study showed the increase in environmental pollution and recommendation to facilitate green logistics.

Erkan [11] looked at the connection between the infrastructure-weighted indicators of the GCI and the LPI. The infrastructure components of the GCI that were used are quality of roads, quality of railroad infrastructure, quality of port infrastructure,

quality of air transport infrastructure, value chain breadth, and company spending on R&D.

A regression analysis was made with data from 113 countries to determine whether there is a significant relationship between the overall LPI score and each of the indicators. The conclusion was that only two of the six indicators (quality of port infrastructure and quality of road infrastructure) have a significant relationship with the overall LPI score [12].

However, among the researched literature there are a very few authors [4] who deal with the examination of the LPI index, its method of calculation since there is no exact data on the calculation of this index so it is wide range of methods that can be used to create prediction models for LPI development.

Data and methodology

Logistics performance index is an important indicator of logistics development of national economy. LPI measurement represents an interactive tool created by the World Bank [2] for tracing improvement of logistics in 160 countries across the world. It allows benchmarking of crucial dimensions that shape the overall LPI score. Key dimensions that generate LPI score are following: customs, infrastructure, international shipments, quality of logistics services, tracking and tracing and timeliness. The dataset for this research was gathered from the World Bank database and it considered timespan from 2007 to 2018. The study was conducted on a global level and considers 160 economy. All six dimensions are evaluated by experts from the field and marked with grades from 1 to 5. Based on the scores obtained by experts overall LPI is determined. Each survey respondent evaluates eight overseas markets based on six key logistics performance indicators. The eight countries are selected on the basis of the most important export and import markets of the country in which the respondent is located. If the respondent's country is landlocked, then the selection is done on the basis of neighboring countries in the logistics chain that connect them with international markets [4]. The global dataset was distributed to six continents in order to compare the evaluation score of LPI and six key dimensions according to the location. Distribution of the obtained LPI scores according to the continents is presented in the Figure 1 to Figure 6. Figure 1 is illustrating the distribution of the overall LPI score in Europe and it highlighted Germany (4.2) as the best ranked economy followed by Sweden (4.05), Belgium (4.04) Austria (4.03), Netherlands (4.02) and the rest of the countries. The lower LPI score was reached in Moldova (2.46), Belarus (2.57) and Albania (2.66). The LPI ranking discovered high oscillations among high-income and low-income economies.

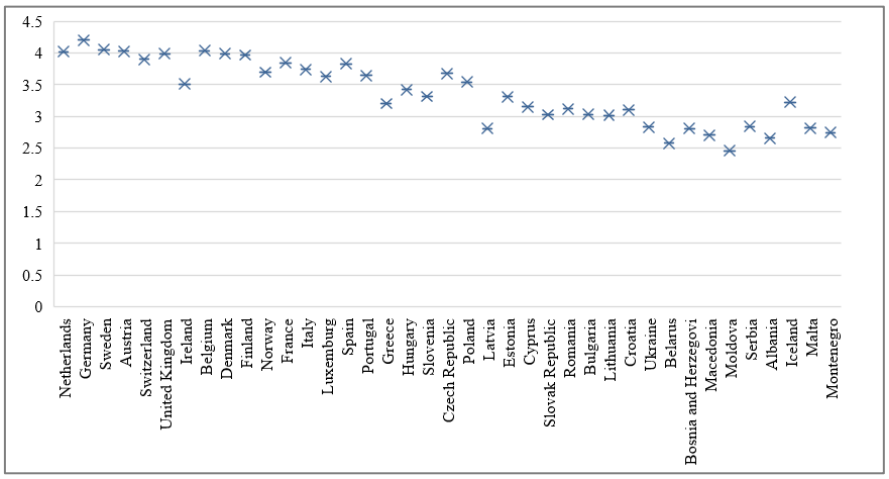

Figure 1 Overall LPI score for European countries in 2018 [2].

sFigure 2 is describing achieved LPI score in Asian countries in 2018. The best results are obtained in Japan (4.03) and Singapore (4), followed by United Arab Emirates (3.96) and Hong Kong (3.92). Afghanistan (1.95), Libya (2.11), Bhutan (2.17) and Iraq (2.18) record the lowest score in the overall LPI. It is evident that the ranking of the overall LPI in Europe and Asia are following the economic development of countries.

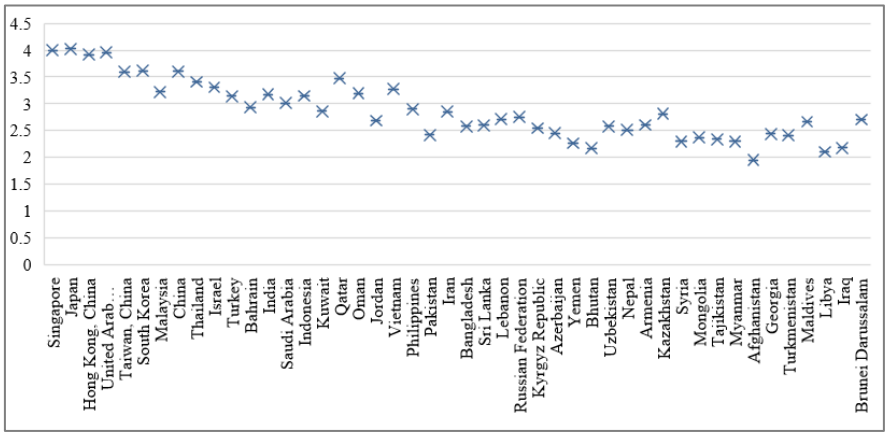

Figure 2 Overall LPI score for Asian countries in 2018 [2].

Furthermore, Figure 3 is presenting the results of the LPI measurements in 2018 conducted in Africa. The highest result was recorded in South Africa (3.38) that is far below than highest scores in Europe and Asia. The rank of South Africa is in the

line with European countries like Hungary, Slovenia or Estonia. While the lowest results were obtained in Angola (2.05).

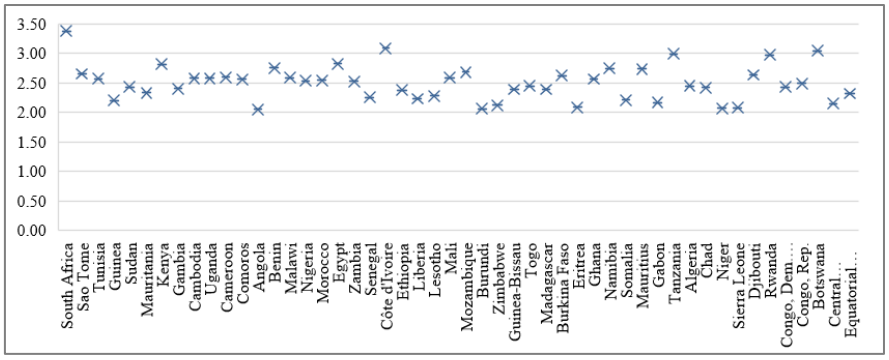

Figure 3 Overall LPI score for African countries in 2018 [2].

In addition, Figure 4 is illustrating the results of the LPI score for 2018 in South America. The leaders in logistics development are Chile (3.32), Brazil (2.99) and Colombia (2.94). Result obtained in Chile is approximately to the result obtained in South Africa. On the other side Venezuela recorded the lowest result of the overall LPI score (2.23). Low variation in the LPI score in 2018 is characteristic for countries in South America.

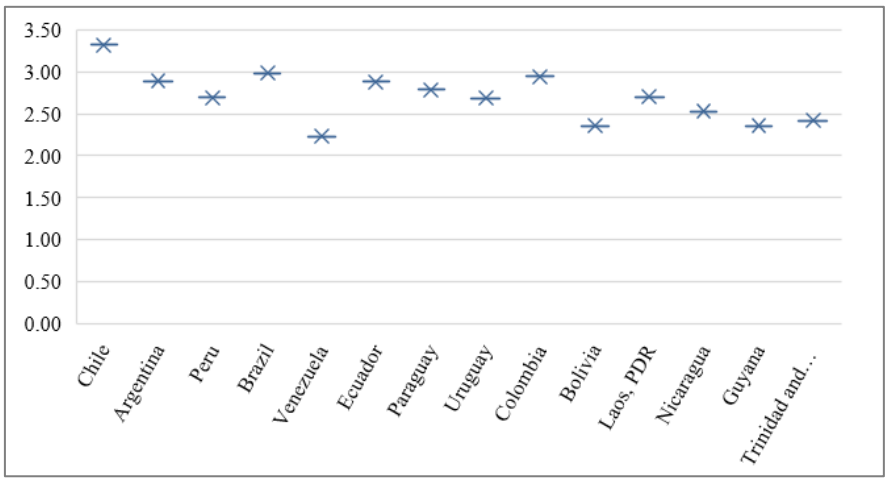

Figure 4 Overall LPI score for South American countries in 2018 [2].

The logistics performances evaluated in North America in 2018 are illustrated in the Figure 5. Pioneers in logistics development are United States (3.89) and Canada (3.73), while Haiti (2.11) records the lowest score.

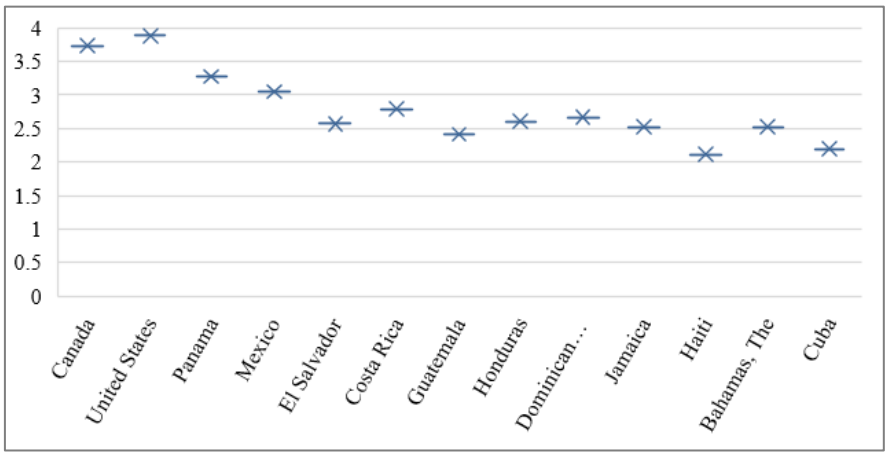

Figure 5 Overall LPI score for North American countries in 2018 [2].

Finally, the LPI score for Australia and Oceania are presented in the Figure 6. The outcome results of the LPI measurements place New Zealand (3.88) as the leader in LP and puts Papua New Guinea (2.17) at the bottom of the ranking list.

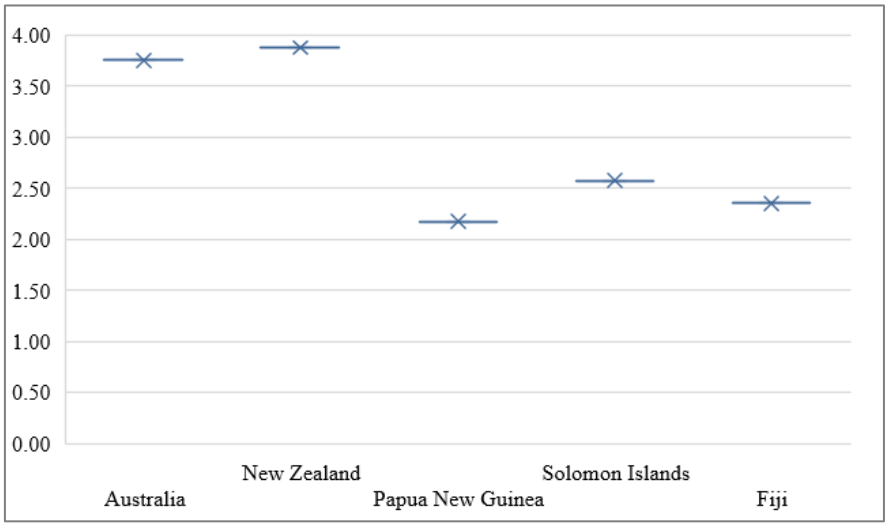

Figure 6 Overall LPI score for Australia and Oceania countries in 2018 [2].

In addition, the key dimensions that were used for calculating overall LPI score were presented in the Figure 7. Graphical illustration below allows comparison of average LPI score according to each dimension across six continents. The dimensions were evaluated with the highest scores in Europe that brings to the conclusion that Europe is the leader in development of logistics performances.

Australia and Oceania along with Asia achieve similar scores of the LPI dimensions. The next in the ranking are North America and South America, while the last ranked is Africa.

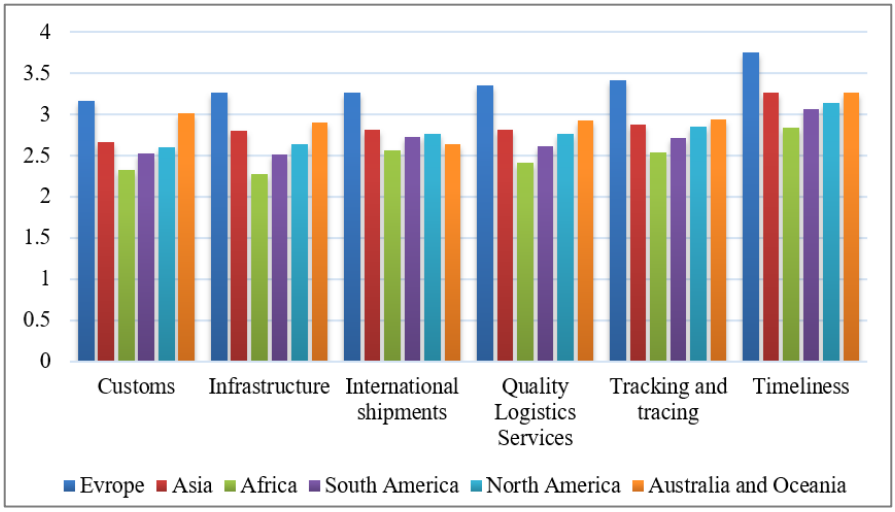

Figure 7 Average score of LPI dimensions for six continents from 2007 to 2018 [2].

The obtained comparisons provided interesting results for further analysis of the key variables. Therefore, the main idea of this research was to use the evaluations of all six dimensions and incorporate them into the prediction model to check the prediction power of the variables. The constructed dataset refers to the evaluation of the global LPI, therefore the results of the analysis presented in the next section are concerning global LPI outcome.

In this paper artificial neural network (ANN) was utilized to create a prediction model using the independent variables to predict the dependent – Logistics performance index. One of the most prominent of digital technologies is artificial intelligence (AI), defined as the capability of machines to communicate with, and imitate the capabilities of humans. Using AI leads to problem solving with higher accuracy, higher speed and a larger amount of inputs. Technological developments have shown that AI has a vast set of applications making headlines by adapting processes in numerous diverse areas including supply chain management (SCM) [13] Artificial Neural Network is a network of simple processing elements called neurons. Artificial neural networks have a natural tendency to save a past data (knowledge) and after learning it, make it available for future use [14].

ANNs can be used for classification, pattern recognition and function approximation and forecasting. Before the development of ANN models, these tasks were carried out by statistical methods such as the linear and nonlinear regression.

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The domain of application is wide and includes fields such as the finance, sales, economy, forensic science etc [14].

A multilayer perceptron (MLP) is a deep, artificial neural network. It is composed of more than one perceptron. They are composed of an input layer to receive the signal, an output layer that makes a decision or prediction about the input, and in between those two, an arbitrary number of hidden layers that are the true computational engine of the MLP. MLPs with one hidden layer are capable of approximating any continuous function [14].

Results and discussion

Research process in the study includes several research phases that follow the order of performing statistics analysis of the data as the first phase, calculating Pearson's correlation among variables that is the second phase and the third phase is constructing ANN prediction model. The most important outcomes of the previously mentioned phases are presented in the following part of the study.

First research phase. Insight in the diversity of the data that were considered in the study was provided by employing several descriptive statistics measurements that was the first phase in the analysis. The results of the descriptive statistics were summarized and reported in the Table 1. The main findings provided by the minimum and maximum values suggest that evaluation marks for variables range from 1.00 to 4.80 where tracking and tracing represent variable with the minimum evaluation mark and timeliness represents the variable with the maximum evaluation mark. Mean evaluation mark for the variables is higher than 2.71 for each individual variable. The lowest mean evaluation is recorded for infrastructure, while the highest evaluation mark belongs to the timeliness. Standard deviation is between 0.53009 and 0.69814 while variance range between 0.281 for international shipments and 0.487 for infrastructure.

Table 1 Descriptive statistics.

	Range	Min	Max	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Overall LPI score	3.02	1.21	4.23	2.8542	.01911	.58604	.343
Customs	3.10	1.11	4.21	2.6529	.01974	.60511	.366
Infrastructure	3.34	1.10	4.44	2.7057	.02277	.69814	.487
International shipments	3.02	1.22	4.24	2.8257	.01729	.53009	.281
Quality Logistics Services	3.07	1.25	4.32	2.7970	.02033	.62316	.388
Tracking and tracing	3.38	1.00	4.38	2.8657	.02103	.64485	.416
Timeliness	3.42	1.38	4.80	3.2662	.01949	.59764	.357
Valid N (list wise)	940						

Second research phase. Next phase in performing analysis was to determine the coefficients of the correlation among selected variables in respect to the overall LPI score using Pearson's correlation. The results of the conducted calculation are presented in the Table 2. In order to take into consideration any variable their statistical significance needs to be computed and the value needs to be lower than 5% ($p<0.05$). Accordingly, all relationships are characterized by acceptable level of statistical significance ($p=0.000$). The strongest positive correlation is recognized between quality logistics services and overall LPI score ($r=0.977$). Described relationship highlights the importance of good logistics services for the LPI ranking and improving. However, the impact of the infrastructure cannot be neglected when analyzing LPI since the correlation coefficient between those two variables equals to 0.970. The rest of independent variables that are tacking and tracing ($r=0.965$), customs ($r=0.958$), international shipments ($r=0.935$) and timeliness ($r=0.933$) reach high correlation with LPI. The outcome of the correlation analysis showed slight differences between the values of the correlation coefficients that point to the approximate importance of independent variables towards the LPI as the dependent variable. In general, the results of the Pearson's correlation showed high positive association among all variables. This means that all independent variables are highly important for the score of the global LPI.

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Table 2 Correlations.

		Overall LPI score	Customs	Infra-structure	Inter-national shipments	Quality Logistics Services	Tracking and tracing	Timeliness
Overall LPI score	Pearson Correlation	1	.958**	.970**	.935**	.977**	.965**	.933**
	Sig. (2-tailed)		.000	.000	.000	.000	.000	.000
Customs	Pearson Correlation	.958**	1	.943**	.865**	.932**	.900**	.854**
	Sig. (2-tailed)	.000		.000	.000	.000	.000	.000
Infrastructure	Pearson Correlation	.970**	.943**	1	.878**	.950**	.920**	.871**
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.000
International shipments	Pearson Correlation	.935**	.865**	.878**	1	.894**	.881**	.849**
	Sig. (2-tailed)	.000	.000	.000		.000	.000	.000
Quality Logistics Services	Pearson Correlation	.977**	.932**	.950**	.894**	1	.939**	.890**
	Sig. (2-tailed)	.000	.000	.000	.000		.000	.000
Tracking and tracing	Pearson Correlation	.965**	.900**	.920**	.881**	.939**	1	.893**
	Sig. (2-tailed)	.000	.000	.000	.000	.000		.000
Timeliness	Pearson Correlation	.933**	.854**	.871**	.849**	.890**	.893**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

Third research phase. After analyzing descriptive statistics and Pearson's correlation outcome it is necessary to initiate the next phase in the analysis. The next step is to apply ANN methodology to create ANN prediction model using the independent variables to predict the dependent LPI. For that purpose, a total number of 966 considered data were divided into training and testing sample equal to 69.3% and 30.7% successively. The structure of the established artificial network that is illustrated in the Figure 8. was set up of three layers that consist of various neurons. Six independent variables were used to build up the input layer of the ANN prediction model. The model considered two hidden layers. Overall LPI was determined as the output layer. The model performance was evaluated based on the sum of squares error (SSE) and relative error (RE) for both training and testing sample. SSE result for the training sample was 0.316 with relative error of 0.001, while the SSE result of the testing sample was 0.166 with 0.001 relative error. Obtained error results imply on the acceptable estimation ability of the ANN model.

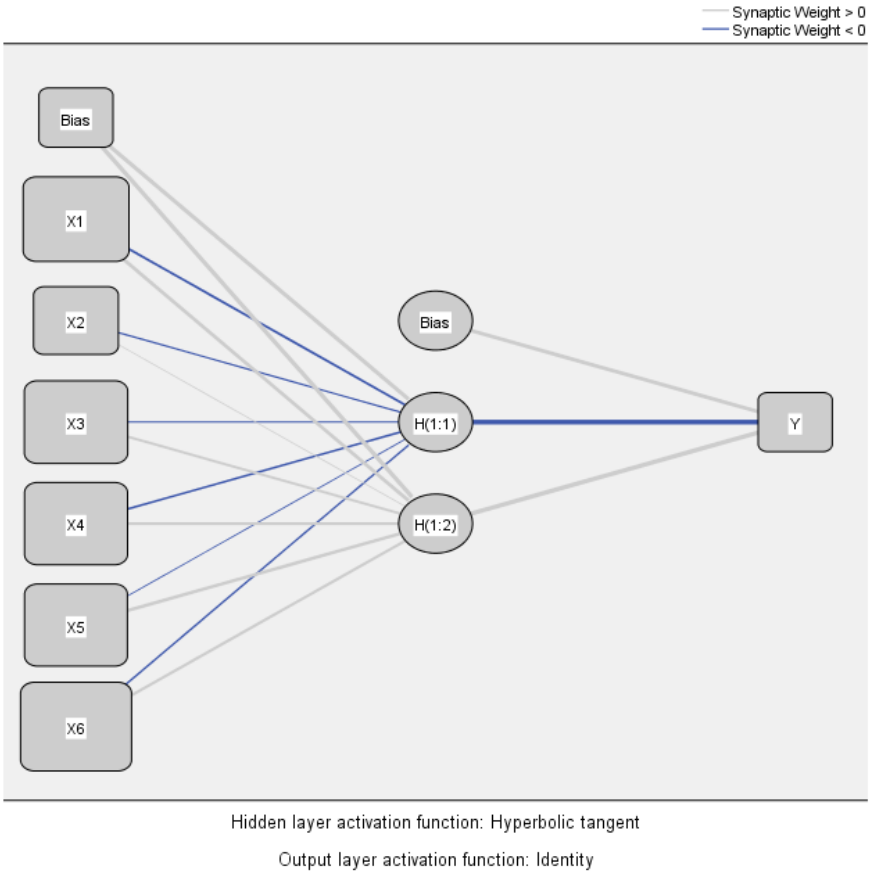

Figure 8 Artificial Neural Network.

The prediction ability of the constructed ANN model is excellent and empirical evidence for that can be found in the estimations that are presented in the following Figure 9 and Figure 10. The graphical representation of the comparisons show low deviations that confirm good model fit.

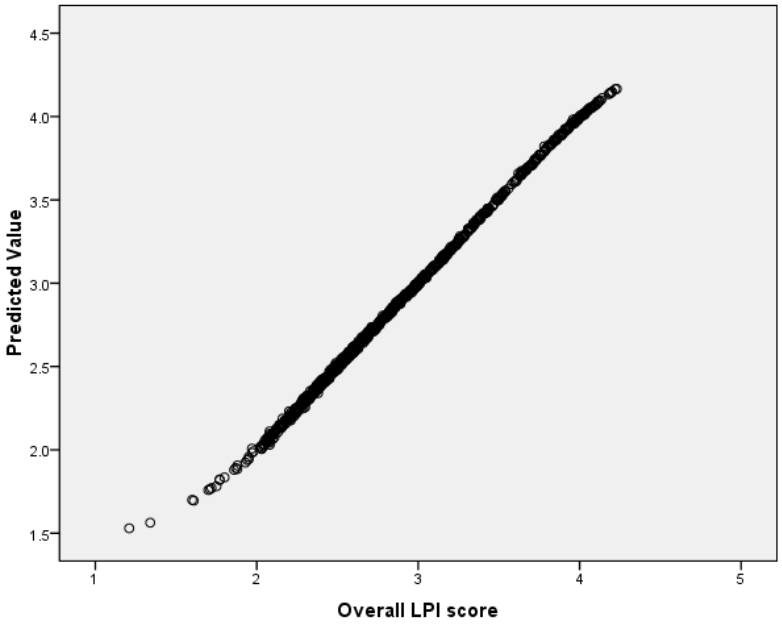

Figure 9 Comparison of realized LPI values and predicted values.

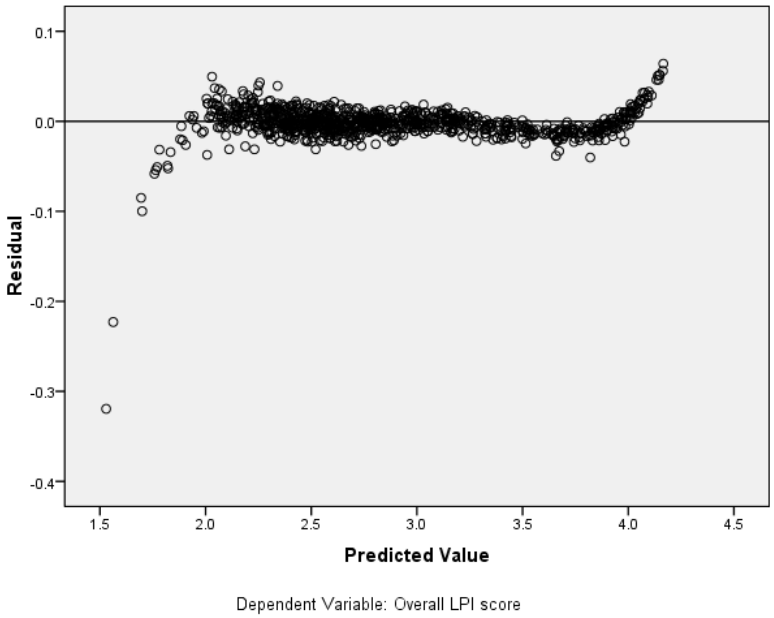

Figure 10 Comparison of predicted LPI values and residuals.

Further investigation of the input layer in the ANN model is based on the consideration of six independent variables. Their individual impact on the overall LPI score is reported in the Table 3. Empirical evidence showed approximately similar impact of variables that range from 0.123 to 0.190. The lowest impact is perceived in the case of the infrastructure variable, while the strongest impact is recognized in timeliness. Variables tracking and tracing, quality logistics services and international shipments express minimal difference in the level of influence. The nature of the outcome results suggests that all investigated variables are important in predicting future trends of LPI score. In other words, there is no specific independent variable that achieves higher influence than others and that should be considered separately.

Table 3 Independent variable importance.

	Importance	Normalized Importance
Customs	.177	92.9%
Infrastructure	.123	64.5%
International shipments	.171	89.7%
Quality Logistics Services	.170	89.2%
Tracking and tracing	.169	89.0%
Timeliness	.190	100.0%

Figure 11 is illustrating impact of each independent variable on the dependent variable LPI expressed in percentages.

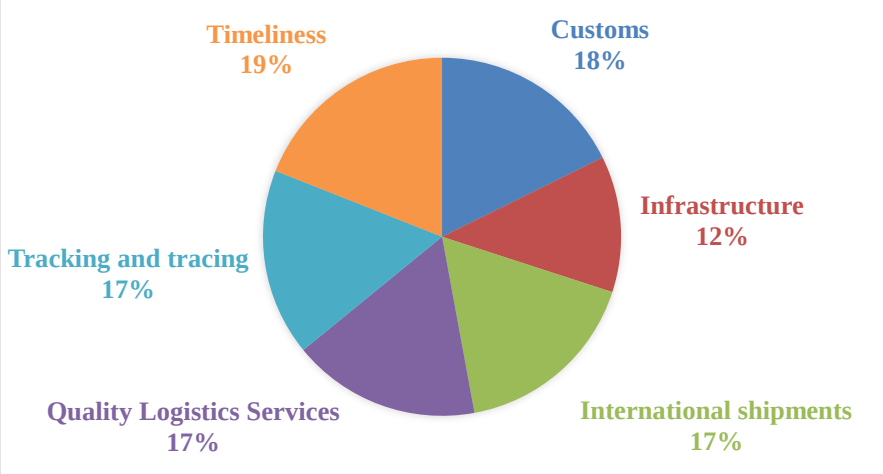

Figure 11 Individual importance of the independent variables.

Various conclusions can be made when conducting a comparison analysis of the results obtained by Pearson's correlation and ANN methodology. Empirical evidence from both analysis highlight the strong positive linkage between the independent and dependent variables. The most important relationship among them according to the Pearson's correlation coefficient is the relationship between LPI and the quality of logistics services (r=0.977). On the other side, ANN methodology offered different ranking of the independent variables importance and puts timeliness as the variable with the strongest impact on the LPI score. Share of 19% of the variables importance weight in respect to all variables belongs to the variable timeliness.

Another interesting observation is that according to the Pearson's correlation the variable namely infrastructure holds second position with correlation coefficient of 0.970 while the same variable is ranked as the least influential on the LPI with only 12% share of individual importance for the LPI score. However, the results that were further analyzed are ANN outcome results of the global LPI. The prediction model for the global LPI provided valuable predicted estimation with no major deviations. When looking at the individual importance weights of independent variables, ANN methodology is underlying the high importance of the timely deliveries to the customers in respect to the other variables. By improving the timeliness of delivery, the efficiency of the logistics process would improve resulting in higher overall LPI score. Nevertheless, decreasing the time needed for delivery is not an easy task since it depends on many internal and external factors. Some of those factors are other independent variables that were included in this study like for example infrastructure or customs. Therefore, secondly ranked variable is referring to customs. International shipment means crossing the border

of one or more countries to deliver the shipment into the destination country. The efficiency of the custom process is determining the time that is spent on handling shipments in the borders. Therefore, it is essential to prevent any delays caused by customs. Possible difficulties that can occur may be, for example, the consequence of technical or legislation nature. When talking about legislation problems, the role of the government is crucial in regulating the customs procedures. Many countries have already formed alliances or trade unions that secure faster and reliable customs procedures. Such example is European Union that assure shorter time spent in transition within its territory. More of these unions and agreements on international level between governments are necessary to improve the customs process. In addition, it is expected that reducing the time needed for the customs would reduce the delivery timeliness. This statement is supported by the results of the Pearson's correlation coefficient (r=0.854) for timeliness and customs and confirms that changes in both variables must be in the same direction. Next three variables that are tracking and tracing, quality logistics services and international shipments achieve almost the same share (≈17%) in their individual importance weights towards the global LPI score. In logistics, tracking and tracing are crucial processes for providing exact information of the shipment location in real time and securing the successful shipment delivery. Furthermore, assessing quality of logistics services and international shipments cannot be possible without adequate following infrastructure. Poor infrastructure is driving away potential foreign investors. In this study, ANN prediction model classified infrastructure as the sixth ranked variable important for the global LPI with a bit lower importance weight of 12%. Infrastructure and good connectivity between cities, countries and continents is the key of successful trading. The more developed transportation infrastructure means higher competitiveness of the economy and attraction of additional foreign investments. Trading and logistics are supporting the economic development of every society so for achieving higher economic growth it is necessary to invest in routes and other following infrastructure.

All six indicators that have been used in the study to are very important in determining the speed of globalization and provides the idea on how far is a specific country, region or continent developed and organized in the field of logistics. The foundation of the globalization is seen in global connectivity and exchange of people, goods and money without any obstacles. The development extent of the LPI score can decide on weather country is marked as attractive for international trade and transportation or not. Overall LPI score of countries allows identification of logistics indicators that provide great results or achieve low outcome. Therefore, the LPI measurement provides possibilities to compare logistics improvement of economies in different regions. Any kind of improvement of LPI indicators can bring to regional cooperation and increase of international trading flows.

Conclusion

International cooperation is gaining momentum in trade. In order to make products and services available to all interested customers governments of various countries sign various cooperation agreements. The market is becoming global and competitiveness is strengthening. All these are the consequences of globalization. In order to survive in the global market, countries must ensure the competitive advantage of their products and ensure good business conditions in the domestic market in order to attract foreign investors. The development of logistics is one of the important indicators of the country's attractiveness for attracting foreign funds. In order to measure the development of logistics and to be able to compare these measurements at the global level, a logistics performance index was created. Logistics performance indicator is a relatively new tool for analyzing and comparing the level of logistics development in every country that was first introduced in 2008. The results of the LPI are useful for gaining knowledge about the various questions in the logistics field such as the state of infrastructure in particular country, the efficiency of the customs procedures, time needed for delivery, efficiency of the tracking and tracing process and handling the international shipments. However, to be able to use LPI data it is necessary to understand their nature and internal relationship among them. This research was based on the problem of analyzing and predicting the values of LPI by employing six LPI indicators. The calculation procedure for the LPI was not explicitly defined so it is convenient for researchers to apply different models to find appropriate methodology for future calculations.

The main research results of this study provided few interesting observations and the most important of them are highlighted. Conducted Pearson's correlation analysis showed high positive correlation coefficients for all independent variables in respect to the overall LPI score. The detected correlations provided statistically significant results. The strongest correlation of LPI is recorded with independent variable namely quality of logistics services (r=0.977). The detected correlations of LPI with the rest of the independent variables range from 0.933 to 0.970. However, the outcome of the Pearson's correlation that describes the relationships among independent variables imply on high positive linkage between them. This means that all variables express high positive connectivity with the overall LPI and any improvement in individual variables would induce improvement of the overall LPI score. The LPI overall score was predicted using ANN prediction methodology. Estimations provided by the model for predicting global LPI score expressed good fit of the model without any major deviations. As a part of ANN methodology, the importance of individual variables described as input ANN layer was determined towards global LPI score that generated output ANN layer. Outcomes of the importance calculation showed approximately equal importance weights of considered variables that range from 12% (infrastructure) to 19% (timeliness). Accordingly, the individual importance weights calculated by ANN confirmed the

results of the Pearson's correlation coefficients stating that all variables are important for improving LPI score. It leads to the conclusion that governments should develop each of these six fields simultaneously. Also the improvement of an individual variable can provoke improvement in other variables so the regulation of logistics issues and challenges should be considered carefully. Governments should take into consideration to adopt legislation and policies that are harmonized with global logistics trends. Their policy should be focused towards creating new agreements and unions that foster the development of logistics process and regional collaboration. The most effective way of using past LPI scores is to plan long-term strategic targets with the help of prediction models that can be used to estimate future values of the LPI. Another advantage of using prediction models in evaluating LPI is the emerged possibility to simulate the effects of variables on the total LPI score. Obtained simulation results could be used in formulating policies and legislations that arrange the field of logistics. Future research could be directed towards employing additional parameters that are of interest in logistics.

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