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Methodology and Model of Technologistics Index

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Abstract

In today's competitive landscape, it is necessary for firms and countries to maintain a competitive edge so as to gain a new consciousness by bringing together technological knowledge and logistics mind. The name of this consciousness is Technologistics. Technologistics is a consciousness that provides a sustainable competitive advantage and advanced company performance to the firms that adds technological base and logistics mind to its management and operation processes. In this paper, it is aimed to develop an index to rank countries in terms of Technologistics performance. Therefore NRI, GII, LPI have been used and these indices have been linked to GDP according to the methodology of the new index. As a result of this paper, TLI was proposed as the most prominent indicator of competitive advantage.

Jel Classification Codes: F1, C3, O5, R4

Keywords: Logistics performance index (LPI), Networked readiness index (NRI), Global innovation index (GII), Gross domestic product (GDP), Structural equation modelling (SEM).

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I. Introduction

In recent years, technological developments have led to radical changes in all processes ranging from supply management to production management, from distribution management to customer relationship management, from after-sales service management to reverse logistics. This situation also changes the competition style of countries. Now, as countries compete with each other, they have started to use the factors such as technology, innovation, speed rather than the factors such as product, quality and price. Firms have understood that the production processes which are added including technological knowledge or logistic mind cannot be separate in order to be successful. Therefore, today's competitive landscape is necessary for firms and countries to gain a competitive edge thereby acquiring a new consciousness by bringing together technological knowledge and logistics mind. The name of this consciousness is Technologistics. Technologistics is a consciousness that provides sustainable competitive advantage and advanced company performance to the firms that adds technological base and logistics mind to its management and operation processes. The firms that will act with this consciousness are called Technologistics Firms. Technologistics firms will not only compete in the future but also will be the determinant of this competition. Countries will take competitive advantage if they develop policies and strategies to gain Technologistics consciousness. Today, a number of indices have been developed indicating the technological developments of the countries. Among these, the most recognizable ones in the international area are the Networked Readiness Index (NRI), the Global Innovation Index (GII) and the Global Entrepreneurship Index (GEI). In the same way, the index ranking the countries' logistics performances is the Logistics Performance Index (LPI). In the literature, Gross Domestic Product (GDP) is used as a dependent variable when measuring the superiority of the countries in the area of logistics, innovation, entrepreneurship and competitiveness.

In this paper, it is aimed to develop an index to rank countries in terms of Technologistics performance. Therefore NRI, GII, LPI have been used and these indices have been linked to GDP according to the methodology of the new index. Theoretical background and hypotheses development, methodology and conceptual model and analysis results are explained in the following sections of this paper. In the conclusion of paper, the results of the analysis are interpreted and limitations are explained and future researches are recommended.

II. Theoretical Background & Hypotheses Development

Globalization and the increasing competition reveal the critical impact of logistics, especially in international trade. Logistics plays a critical role in the preparation of performance indicators of a product on national level promptly and safely by considering all costs efficiently and effectively, developing efficient policies and implementing such policies. In this respect, the Logistics Performance Index (LPI) is the most comprehensive international comparison tool for measuring the trade and transport facilitation friendliness of countries (Ojala and Çelebi 2015).

A. Logistics Performance Index (LPI)

In the study, LPI is used as the first index for evaluating performances of countries in the logistics fields such as customs, transportation and infrastructure, and measuring quality through logistic growth. It aims to provide information on what can be done for reducing logistics problems encountered in international trade (TUİK, 2014). Logistics Performance Index is announced by the World's Bank. It is based on an evaluation of survey results from various reliable sources. The index which was first published in 2007, was then published respectively in 2010, 2012, 2014 and finally in 2016. The aim of the logistics performance index is to compare logistics performance profiles of countries. LPI is an index evaluating feedbacks of the

participants in the countries with which they trade, and thus carry out logistics activities, using the survey conducted worldwide. Informed qualitative assessments of the participants are combined with their global logistics environment experiences (Šımkova and Stopka 2014). The index measures the performance along the logistics supply chain within a country through two different perspectives. One of them is International Logistics Performance Index, another one is Domestics Logistics Performance Index. This study employed the International Logistics Performance Index. The International Logistics Performance Index consists of surveys including qualitative assessments of the logistics professionals. It includes six different dimensions. The participants are chosen from foreign logistics professionals. The LPI rates the trade and logistics profile of a country on a scale of 1 (worst) to 5 (best). The ratings are based on more than 6000 individual country assessments by nearly 1000 international freight forwarders, who rated the 8 foreign countries their company serves most frequently. A separate country score is calculated for each component. The LPI's 6 components include; Customs, Infrastructure, International shipments, services quality, timeliness, tracking and tracing. The Principal Component Analysis (PCA), being one of the standard statistical techniques, is used for creating the 6 basic dimensions of the LPI. The average of the country scores from the questions constitutes the input of the PCA analysis. These scores are normalized by considering standard deviation and mean value before conducting PCA. And the output of the PCA is the dimensions (Arvis J. F. et. al. 2014). To construct the LPI; normalized scores for each of the six original indicators are multiplied by their component loadings and then summed. Since the loadings are similar for the components of LPI, the LPI scores of the countries are close to a simple average of the indicators (Arvis J. F. et. al. 2012). The Logistics Performance Index has been used by many researchers in their studies. Burmaoğlu (2012) study analyzed the impact of the innovation indicators for the year 2009 in the EU countries on the logistics performance. It was found using correlation analysis that the human resources and intellectual assets have a positive impact on logistics performances of countries. Erkan (2014) study investigated the correlation between the global competitiveness index and the Logistics Performance Index through linear regression. Puertas et al. (2013) study revealed the conclusion that logistics were more important for exporting than importing for 26 EU countries between the years 2005 and 2010 by using the gravity model. Vilko et. al. (2011) study investigated the relationship between logistics infrastructure and economic development in their study conducted in 2011. Roy (2011), analyzed the relationship between Logistics Performance Index and business productivity of Canada. He revealed that business productivity affects logistics performance and supply chain management of the country positively. Mohan (2013) study analyzed the relationship between logistics management and competitiveness was examined within the example of India. The study concluded that India should improve its transportation infrastructure and attach more importance to storage to be able to increase its logistics performance. Founou (2002) study examined the effect of the use of computer technologies in logistics management on competitiveness. As a conclusion, use of information technologies in the logistics industry increases productivity and competitiveness. Sanberg and Abrahamsson (2011), investigated the importance of logistics on sustainable competitiveness, and they concluded that effective use of information technologies in logistics activities increase competitiveness and provide sustainability.

B. Network Readiness Index (NRI)

Second index Network Readiness Index (NRI) is used for ranking the countries in the ICT competency level (The World Economic Forum, 2007). In the advent of Information and Communication Technologies (ICT), networked information societies have started to emerge. In this context, "The Global Information Technology Report" released by the World Economic Forum (WEF) (2007). This report has recommended NRI as a measure of the global competitiveness of a country in ICT area. Especially after the emergence of the internet, NRI provide an indicator for researchers. NRI is to denote readiness degrees of IT industry and participation degree of individuals. In the extant literature, there have been several studies on the

relationship between the NRI and GII. Teng & Yeh, (2008) constructed the research upon Mahalanobis-Taguchi System (MTS) to posit a NRI model. In the context the theory of diffusion of Innovations, Lavassani, Movahedi & Kumar, (2008) studied on the readiness levels of countries in the individual and business usage of digital content. Choosri, Yu and Atkin (2009) asserted that NRI is to measure country's ICT capabilities under three dimensions. First dimension covers readiness of governments, businesses, and individuals to effectively utilize ICT. Second dimension covers general ICT regulations, business, and infrastructure environment. Third dimension covers usage of available technology. For better understanding the casual relationships, a study is carried out by Wei-Wen Wu and the others in 2012. With this purpose, they used data mining techniques and partial least squares structural equation modeling to clarify the critical constructs within the NRI. They also explained the causal relations amongst these constructs. They indicated that “business usage”, “business readiness” and “market environment” are the three important constructs. Soldić-Aleksić and Stankić (2015) suggested the conceptual framework of the NRI proposed by the World Economic Forum. In their study, they analyzed the relative position of Serbia. They resulted that Serbia has the poorest performance in the NRI by comparing other EU countries.

C. Global Innovation Index (GII)

The Global Innovation Index (GII) is used as the third index which offers a holistic and comprehensive analysis not only measuring research and development, but also the development of technological progress, project numbers, and so on. Innovation input sub-index consist of GII such as Institutions, human capital and research, infrastructure, development of markets, commercial development and innovation output sub-index consist of information and technology outputs such as creative outputs. The innovation index is viewed as a tool to measure national competitiveness and to develop the processes of forecasting that help to see the past, the present and the future prospect (Wonglimpiyarat 2010).

D. Gross Domestic Product (GDP)

Innovation also affects the economic development, employment and competitiveness of the countries. The GII focuses on both the development of innovation measurement and innovation. It also helps to create an environment in which the elements of innovation are constantly evaluated. This provides a detailed metric key that includes 141 economies each year. It represents 95.1% of the world's population and 98.6% of the world's Gross Domestic Product (GDP). GDP was chosen for an important variable in the research due to being a developed indicator of economic growth (Insead and Wipo 2015; Insead and Wipo 2013; Insead and Wipo 2012). Many studies indicate that the growth of economies is crucial, given the growing challenges of innovation, globalization and global competition. These studies clearly demonstrate the importance of GDP and GII (Breznitz and Murphree 2011; Klochikhin 2012). The successive and step-by-step innovation model of internal growth theories classified as the third generation is firstly recommended by Budd et al. (1993). The beginnings of economic growth theories are based on Frank Ramsey's study titled "A Mathematical Theory of Saving" in 1928. In this context, Harrod (1939) and Domar (1946), Solow and Swan (1956) developed the theory of growth models. The Solow-Swan growth model, which has a decreasing return relative to the scale, assumed that the technology is an external variable. At the same time, it was emphasized that the grower would follow a static course (Genc and Atasoy 2010). A neoclassical model (Solow-Swan), which has an important place in economic literature, has left its place to theories of internal growth after 1980's. These models have increased yields on a scale basis in the production function. Technology is taken as an internal variable in this model. The internal growth model, which is called Schumpeter is emphasized that technology is an internal phenomenon that will be transformed into inventions and innovations in production (Aghion et. al. 2009; Göçer 2013) and it is accepted that the driving force of economic growth is the technological competition (Fagerberg 2004).

There have been several studies in the literature regarding the factors affecting innovation (input and output) and the relationship between these factors at macro and micro level. Some of these studies are shown below.

Akman and Okay (2013) study used a literature data on the activities and the sectors targeted by ESCOs in 38 countries, summarized in terms of the age of ESCO market. Along with the Global Innovation Index (GII) data of the countries, they investigate the relationships among the ESCO Indicators and the Country Indicators such as GII and per-capita GDP. They found significant dependencies between the ESCO indicators and Country indicators by using the simple trend equations.

Güloğlu and Tekin (2012) study examined the causality relationship between invasion and economic growth between 1991 and 2007 for the selected 13 OECD countries and found that there is a bi-directional causality between technological innovation and economic growth.

Ülkü (2004) study surveyed the relationship between innovation and economic growth between 1981-1997 for 10 non-OECD countries and 20 OECD countries and found that a total 30 countries have a positive and significant relationship between innovation and economic growth.

Esteves and Feldman (2016) they have done a quantitative study by using the multiple linear regression procedure to ascertain which factors are most appropriate for the distribution of countries in the Global Innovation Index. As a result, GDP is in the decreasing order of "public expenditures for R&D", "exports of high technology products", "public expenditure on education", "number of large companies" and "innovation". The only variable that is negatively associated with innovation is the number of patents registered in a designated country; In other words, it can be concluded that patents are not the most relevant indicator associated with the development of innovation. In recent years, due to having an intense competition in the globalized economy, exports are also becoming more sustainable when companies can produce high-quality goods with high technological developments. (Özer and Çiftçi 2009). During the globalization of the world economy, innovations and ideas with the ability to create value strongly based on an economic growth.

In this Paper the relationships among the LPI, GII, NRI and GDP has been investigated.

Hypotheses of the research are as follows:

H1: Logistic Performance Index has a positive effect on Global Innovation Index.

H2: Networked Readiness Index has a positive effect on Global Innovation Index.

H3: Global Innovation Index has a positive effect on GDP.

III. Methodology & Conceptual Model

TLI is a compound weighted measure of information technology, innovation and logistics performance of the countries. In creation of TLI 3 different sub-index have been used. These indexes are LPI, NRI and GII. TLI is formed from weighted mean of these sub-indexes. In order to obtain the weights of each sub-index maximum likelihood regressions have been run. Weight of each sub-index in the formula is calculated by using structural equation modeling. The conceptual model is shown in Figure 1. The base calculation formula is shown hereunder.

$$TLI = \frac{\beta_1.\mathrm{LPI} + \beta_2.\mathrm{NRI} + \beta_3.\mathrm{GII}}{\beta_1 + \beta_2 + \beta_3}$$

β values in this formula refer to effects of each index on GDP. The indirect effect is taken for exogenous variables and direct effect is taken for endogenous variables. In other words, β_1 and β_2 express indirect effects of LPI and NRI on GDP, while β_3 expresses direct effect of GII on GDP. GDP is a fundamental indicator of economic performance of countries. Therefore the effects on GDP are taken as the base of the weighted average formula.

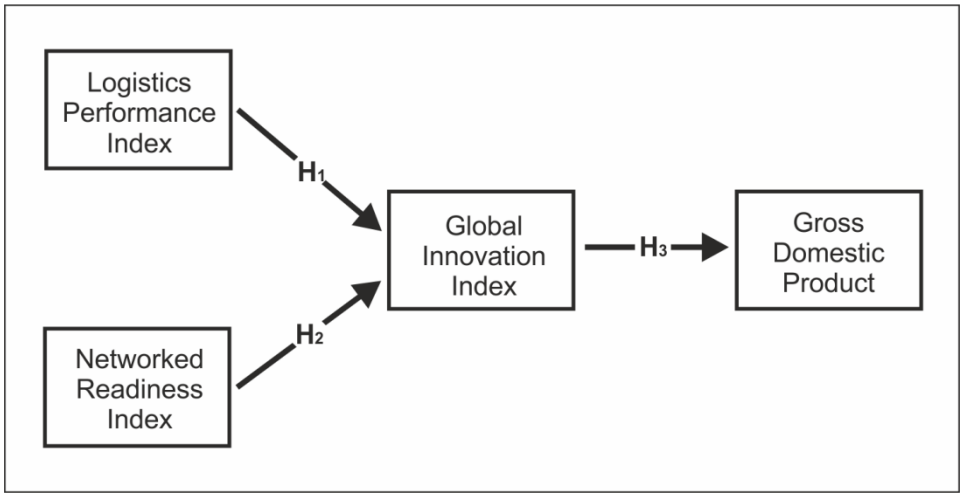

Figure 1. Conceptual Model of TLI

Before performing structural equation modeling, assumptions of linear regression have been detected. Linearity, normality, homoscedasticity and multicollinearity have been detected and these assumptions have been fulfilled.

IV. Analysis Results

The compatibility of the model and the data are evaluated according to fit indices. CMIN/DF, CFI (the comparative fit indice), IFI (the incremental fit indice), RMSA (the root-mean-square error of approximation) are used due to being the recognized indices in the literature (Akgün et. al. 2014).

Table 2. Hypotheses Results

Relationship	**β**	**Result**
LPI → GII	0.246*	Supported
NRI → GII	0.725*	Supported
GII → GDP	0.344*	Supported
Model fit indices	χ2/df=2.605, CFI=0.992, IFI=0.992, RMSEA=0.117	

Note: Path coefficients are standardized.

*p<0.01

Table 1. Shows the correlation results among variables according to Pearson correlation coefficient. As shown in the Table 1. correlations are statistically significant.

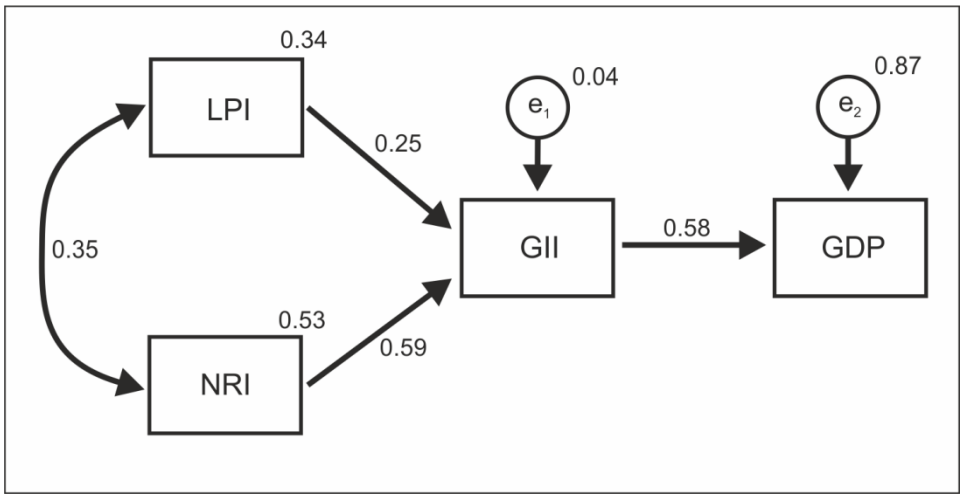

Figure 2. Results of SEM Analysis

The final model is shown in Figure 2 and the results of the hypotheses are shown in Table 2. As shown in Table 2. all the hypotheses are supported.

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In Table 3. indirect effects of the exogenous variables on dependent variable are shown. This indirect effect values are used for the calculation of TLI.

Table 3. Results of Indirect Tests

Independent variables	**Dependent variables**	**Indirect effect**
LPI	GDP	.085
NRI	GDP	.250

Note: Coefficients are standardized

β_1 and β_2 values are taken from in Table 3. These values refer to indirect effect of exogenous variables on GDP. β_3 value is taken from Table 2 which refers to direct effect of GII on GDP. Calculation of TLI is resulted from the combination of indirect and direct effects on GDP. According to formula which is shown in methodology, TLI values for 119 countries are calculated. Consequently TLI values of 119 countries for 2016 are shown in appendix.

$$TLI_{2016} = \frac{(0.085).LPI + (0.250).NRI + (0.344).GII}{(0.085) + (0.250) + (0.344)}$$

V. Conclusion

In this paper it is aimed to develop an index combining technology, logistics and innovation performances. This index is called as TLI. In the research model, weighted average of the effects of NRI, GII and LPI sub-indexes on GDP are used in order to calculate TLI. In terms of calculation formula, 119 countries are ranked according to data of 2016. Thus, TLI was established. As a result, there is a correlation between countries which have high scores in TLI also having high scores in technology, innovation and logistics performance.

Nowadays, depending on the firm or country; being superior alone in technology, logistics and innovation does not provide a competitive advantage. Companies or countries wishing to gain a competitive advantage must have the same superiority in these three areas. Now a company or country that is superior in logistics alone cannot provide absolute superiority in competition because the field of innovation and technology is lacking. Likewise, technological or innovative firms or countries alone cannot have a competitive advantage because they are missing logistics abilities. A technological and innovative business loses its competitive advantage in cases where it is inadequately presented to the customer on a timely basis in products and services offered to customers or when there is a problem accessing the product or service. Similarly, businesses that bring their products or services to customers in a timely and trouble-free manner will lose their competitive advantage if they are not technologically and innovative enough. Hence, it will not be enough for today to be fast only, technologic only and to be innovative only if businesses and countries can gain a competitive advantage. TLI is a demonstration of the skills required to bring together the countries to gain a competitive advantage. As a result of this paper, TLI was proposed as the most prominent indicator of competitive advantage.

Appendix. Technologistics Index (TLI), 2016

Rank	Countries	TLI	Rank	Countries	TLI	Rank	Countries	TLI
1	Switzerland	3,96	**41**	Saudi Arabia	2,82	**81**	Tunisia	2,28
2	Sweden	3,92	**42**	Slovak Republic	2,82	**82**	Iran	2,23
3	Singapore	3,86	**43**	Chile	2,79	**83**	Ecuador	2,23
4	Finland	3,85	**44**	Turkey	2,77	**84**	Jamaica	2,23
5	United States	3,83	**45**	Costa Rica	2,69	**85**	Albania	2,22
6	United Kingdom	3,83	**46**	Croatia	2,68	**86**	D.Republic	2,21
7	Netherlands	3,78	**47**	Russian Federation	2,68	**87**	Egypt, Arab Rep.	2,19
8	Luxembourg	3,72	**48**	Greece	2,67	**88**	Botswana	2,19
9	Germany	3,72	**49**	South Africa	2,67	**89**	B.Herzegovina	2,18
10	Denmark	3,68	**50**	Bulgaria	2,66	**90**	Namibia	2,16
11	Hong Kong SAR, China	3,64	**51**	Thailand	2,62	**91**	Bhutan	2,16
12	Korea Rep.	3,63	**52**	Uruguay	2,62	**92**	El Salvador	2,15
13	Japan	3,60	**53**	Romania	2,59	**93**	Honduras	2,13
14	Canada	3,60	**54**	Panama	2,59	**94**	Cambodia	2,10
15	Ireland	3,60	**55**	Montenegro	2,56	**95**	Ghana	2,08
16	Norway	3,56	**56**	Macedonia, FYR	2,56	**96**	Kyrgyz Republic	2,08
17	Iceland	3,53	**57**	Kazakhstan	2,55	**97**	Paraguay	2,08
18	Australia	3,51	**58**	Oman	2,54	**98**	Guatemala	2,08
19	Austria	3,50	**59**	Mongolia	2,54	**99**	Cote d'Ivoire	2,02
20	Belgium	3,49	**60**	Ukraine	2,54	**100**	Tajikistan	2,02
21	New Zealand	3,49	**61**	Kuwait	2,53	**101**	Uganda	2,02
22	France	3,48	**62**	Moldova	2,53	**102**	Mozambique	2,01

23	Israel	3,44	**63**	Mexico	2,49	**103**	Senegal	2,00
24	Estonia	3,39	**64**	Armenia	2,49	**104**	Pakistan	1,98
25	Spain	3,19	**65**	Georgia	2,47	**105**	Algeria	1,95
26	Czech Republic	3,15	**66**	Vietnam	2,47	**106**	Bolivia	1,93
27	Malta	3,13	**67**	Brazil	2,45	**107**	Tanzania	1,93
28	United Arab Emirates	3,12	**68**	Colombia	2,45	**108**	Bangladesh	1,92
29	Portugal	3,11	**69**	India	2,45	**109**	Nigeria	1,90
30	Malaysia	3,03	**70**	Jordan	2,44	**110**	Ethiopia	1,88
31	China	3,03	**71**	Serbia	2,43	**111**	Nepal	1,87
32	Lithuania	3,02	**72**	Philippines	2,39	**112**	Mali	1,83
33	Italy	3,02	**73**	Sri Lanka	2,36	**113**	Zambia	1,79
34	Latvia	3,01	**74**	Kenya	2,35	**114**	Cameroon	1,77
35	Slovenia	3,00	**75**	Peru	2,35	**115**	Nicaragua	1,76
36	Qatar	3,00	**76**	Morocco	2,35	**116**	Benin	1,76
37	Cyprus	2,96	**77**	Indonesia	2,34	**117**	Madagascar	1,69
38	Hungary	2,91	**78**	Lebanon	2,33	**118**	Burundi	1,58
39	Bahrain	2,88	**79**	Rwanda	2,33	**119**	Guinea	1,53
40	Poland	2,83	**80**	Argentina	2,30			

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