The Relationships Among the Prominent Indices: HDI-GII-GCI

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Abstract Several global indices have been used to classify and to analyze the states of countries. Comparison can be performed not only based on country but also annually for each country. In this study, three prominent indices, the Global Competitiveness Index (GCI), the Global Innovation Index (GII) and the Human Development Index (HDI) were investigated to examine the relationships between them by employing the PLS-SEM method. According to the results, HDI has an influence on GII while GCI is affected by GII. The results also demonstrated that GII has a full mediating effect on the relationship between HDI and GCI. Moreover, findings indicated that countries should improve their innovativeness by taking human capital into consideration to gain competitive advantages.

Keywords Index · HDI · GCI · GII · PLS-SEM · Mediating Relationship

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Introduction

Since ancient times, economies have been challenged to have a competitive advantage over other economies. Over the years, several indices have been created based on different facets of development or economic performance to classify the countries. These indices were an important tool for economies to benchmark themselves compared to other economies in a given year or observe the changing rankings of each economy year to year. In the meantime, each economy can monitor its own trends specifically to identify weaknesses and strengths in each designated sub-index. In the study reported in the present paper, we focus on three prominent indices: The Global Competitiveness Index (GCI), the Global Innovation Index (GII) and the Human Development Index (HDI). The global competitiveness index is used as a tool to evaluate the level of competitiveness; the global innovation index is an instrument to monitor overall innovativeness of countries; the human development index measures parameters of human development and it is widely used to assess the social development of a society (Sirotin and Arkhipova 2014). The aim of the present study is to investigate the relationships among these three indices.

The remaining sections of this paper are organized as follows. Section "Literature Review" covers the literature review of these concepts. Section "Methodology" presents the methodology followed. Finally, findings and conclusion are presented in Section "Findings and Conclusion".

Literature Review

In this part of the paper, the three indices mentioned above will be discussed briefly. Furthermore, past research regarding the interactions between these indices is reviewed.

Human Development Index

The Human Development Index (HDI) has been presented by the United Nations Development Program (UNDP) to assess the level of human development among countries on the basis of composite measurements since 1990. The index started with 144 countries and the last index that is produced in 2015 included 188 countries from all over the world. To measure human development, three dimensions are taken into consideration as long and healthy life, knowledge, and a decent standard of living. Long and healthy life estimation is determined by life expectancy at birth; in other words, the number of years a newborn infant could expect to live if the conditions of age-specific mortality rates remain the same throughout the

infant's life. Knowledge is measured by expected years of schooling and mean years of schooling. Lastly, the decent standard of living dimension is measured by gross national income per capita. After the measurements of these indicators, the average of them is calculated, giving each country a score between 0.00 and 1.00. There is a classification among countries according to the scores they gained. These classes are very high human development [1.00–0.80], high human development (0.80–0.70], medium human development (0.70, 0.55] and low human development (0.55, 0.00]. Moreover, there are also sub-indices such as the Gender Development Index (GDI), the Inequality-adjusted Human Development Index (IHDI), the Gender Inequality Index (GII), and the Multidimensional Poverty Index (MPI) to help to analyze specific areas of curiosity based on descriptive data.

Global Innovation Index

The Global Innovation Index examines innovation progress of countries worldwide along various dimensions. The first GII was conceived in 2007 by INSEAD as a tool to sort out how countries cope with the challenge of innovation (https://www.globalinnovationindex.org/userfiles/file/GII-2007-Report.pdf). After the first edition, 8 more editions were published. The last three editions were presented by a partnership of INSEAD, Johnson Cornell University and the World Intellectual Property Organization (WIPO).

It is important to point out that GII is an evolving measure that is affected by available data and trending concepts; ever changing and developing needs encourage measurement of innovativeness of countries with different indicators. For instance, GII 2014 includes 143 economies and 81 indicators, GII 2015 covers 141 economies around the world using 79 indicators, whereas GII 2016 includes 128 economies and 82 indicators.

The GII consists of two sub-indices: the Innovation Input Sub-Index and the Innovation Output Sub Index. The Input Sub-Index is designed to assess if the countries provide an environment conducive to innovation. Institutions, human capital and research, infrastructure, market sophistication and business sophistication are the indicators to evaluate the conditions. The Innovation Output Sub-Index includes knowledge and technology outputs and creative outputs and is designed to capture how given conditions and opportunities turn into outputs. Each sub index score ranges between 0 and 100, and the final index score is gained by the simple average of sub-index scores (https://www.globalinnovationindex.org/gii-2016-report).

Global Competitiveness Index

Since 1979 the annual Global Competitiveness Report has been presented by The World Economic Forum to shed light on the factors that countries encounter to

achieve competitive advantage. The number of evaluated countries changes year to year due to available data; 138 countries were ranked in 2016–2017 Report whereas 140 economies were listed in the 2015–2016 Report. Altogether there are 12 pillars under three sub-indices to measure competitiveness of economies according to their key factors. The Basic Requirement Sub-Index is a helpful tool for factor-driven economies and its pillars are (1) institutions, (2) infrastructure, (3) macroeconomic environment, and (4) healthy and primary education; the Efficiency Enhancer Sub-Index assesses economies efficiency based on 6 pillars: (5) higher education and training, (6) goods market efficiency, (7) labor market efficiency, (8) financial market development, (9) technological readiness, and (10) market size; the Innovation and Sophistication Sub-Index involves (11) business sophistication and (12) innovation pillars. Innovation-driven economies can use this sub-index as a guide to success. After gathering sub-scores from these three sub-indices, each economy has its own score ranging from 1 to 7.

The Relationships Among Indices

Nasierowski (2016) examined several composite indexes (The World Competitiveness Report Index, the Human Development Index, the Knowledge Economy Index, the Innovation Union Scoreboard, the Global Innovation Index and the Global Competitiveness Report Index) in order to determine their relationships by employing Pearson correlations. He found a strong relationship between the HDI and GII, the HDI and GCI, and the GII and GCI. Fonseca and Lima (2015) also found a high positive correlation between the GII and the GCI. Similarly, Pearson correlation analysis was conducted to capture the relationships among these indices and sub-indices of HDI and GCI. Her calculations were divided into three main parts. In the first part, the correlation between the HDI and GCI was examined. In the second part, the relationship between the GCI and the pillars forming the HDI was investigated. The last part of her study examined the relationship between GCI and GII. All factors mentioned in her study had strong positive correlations (Onyusheva 2015).

There are few studies in the literature that have examined causal relationships among these three indices. Sirotin and Arkhipova (2014) investigated the causal relationship between the GII and the HDI. They found that the best economies according to the GII also had the highest scores on the HDI. On the other hand, Taranenko (2013) used a regression model to show a positive impact of GII on GCI. Similarly, Cvetanovic et al. (2014) examined the relationship between the GII and the GCI of six Western Balkan countries and found GII has a positive but weak influence on GCI.

Although there are several studies on causal and non-causal relationships among indices, a model has not been proposed to test these relationships simultaneously. Moreover, no mediational analyses have been conducted. Therefore, a structural equation model (SEM) was developed in order to analyze the causal relationships

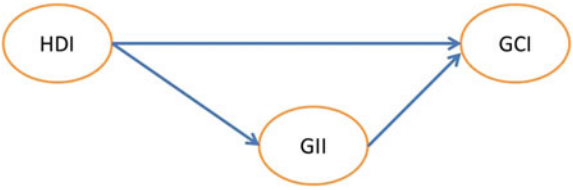

Fig. 1 The model of the study

between these indices with mediating relationships being considered. The model is shown in Fig. 1.

Methodology

In order to explore the interactions in the model, the data were collected from the websites of the corporations. We gathered the latest available data from each index, and the year 2015 was the last year for all of them. Each index includes a different number of countries depending on the responses to the distributed questionnaires. Economies were included in the data of this study if they were listed for more than two indices. After all the eliminations due to the restrictions, 99 economies remained. Different scales were used in each index; consequently, this may cause interpretive problems. In order to evaluate the data on the same scale, normalization was conducted for each of the indices. Finally, all the data ranged between 0 and 1.

The aim of this research to examine causal relationships among the HDI, GII and GCI. To examine the causal relationships among these constructs, simultaneous analysis is required. Partial Least Squares-SEM (PLS-SEM), which is a second-generation technique, was chosen for the analyses for the following reasons. Comprising both a structural and measurement model, PLS-SEM is a nonparametric method (Hair et al. 2011). Moreover, PLS-SEM does not require any distributional assumptions. Hair et al. (2014) suggest using PLS-SEM when the literature is not sufficiently developed. Furthermore, he and his colleagues mention that PLS-SEM is preferable when the main aim is to examine the explanatoriness of a structural model. However, PLS-SEM does not have a goodness of model fit measure to test theory; therefore, confirmation is limited (Hair et al. 2011).

Many researchers from various backgrounds have been conducting PLS-SEM in their research. Some examples of recent studies using PLS-SEM include Calabrò et al. (2017), Moreira et al. (2017), Pai et al. (2014), Vanalle et al. (2017), Wong (2013).

Analysis

In this study, Smart PLS 2.0 software was employed. Structural and measurement models are the elements of PLS-SEM. Additionally, measurement models are divided into two groups, reflective measurement models and formative measurement

Table 1 The statistical significance of the relationships

	Mean	Std. error	t-stats	p-values	Supported/not supported
HDI → GII	0.834	0.029	28.841	0.000	Supported
HDI → GCI	0.264	0.154	1.714	0.087	Not supported
GII → GCI	0.605	0.151	3.895	0.000	Supported

models. In this study, the measurement model is a reflective measurement model that is used when the indicators are caused by the constructs. Reflective measurement models have their own requirements for validity and reliability, and these include a composite reliability higher than 0.70, indicator loadings higher than 0.70, above 0.50 for the average variance extracted (AVE), and discriminant validity that is measured by Fornell-Lacker criterion (Hair et al. 2011). We employed PLS-SEM with a maximum number of 300 iterations and mean replaced missing values. Since our constructs were measured by creating a latent variable with one indicator, the required reliability and validity criteria have all been fulfilled. Composite reliability, indicator loadings and discriminant validity of all constructs were equal to 1. Based on AVE of the highest values, the discriminant validity requirement was also satisfied.

In order to test robustness of the structural model, R^2 values and path coefficients' significance were examined. R^2 values were found to be 0.675 for GCI and 0.693 for GII. Hair and his colleagues suggest that above 0.50 values of R^2 are moderate (2011). A bootstrapping procedure was conducted with 5000 subsamples and mean replacement to estimate significance of relationships, and findings can be seen in Table 1. The significance of relationships is supported if the t-statistics are above 1.96 for a two-tailed test (Hair et al. 2014, p. 186). In other words p values below 0.05 indicate significance.

It was found that the relationships between HDI-GII and GII-GCI is supported, while the relationship between HDI-GCI is not supported. To examine the mediating effect of GII, direct effects between HDI-GCI and HDI-GII-GCI were investigated. Figures 2 and 3 show the models of direct effects.

Fig. 2 Model of direct effects of HDI on GCI

Fig. 3 Model of simultaneous direct effects

Table 2 Direct effects of HDI on GCI

	Mean	Std. error	t-stats	p-values	Supported/not supported
HDI → GCI	0.753	0.047	15.912	0.000	Supported

Table 3 Direct effects of HDI on GII and GII on GCI

	Mean	Std. error	t-stats	p-values	Supported/not supported
HDI → GII	0.834	0.029	28.335	0.000	Supported
GII → GCI	0.809	0.045	18.077	0.000	Supported

Direct effects are significant, as seen in Tables 2 and 3; thereby we can conclude that GII has a full-mediating effect on the relationship between HDI and GCI.

Findings and Conclusion

This study is aimed at investigation of the relationships among three prominent global indices. The literature was reviewed to identify the likely nature of these interactions. Even though some studies addressed the relationships between indices, simultaneous analysis of relationships among these three indices was not found in the literature. This paper filled the gap in the literature by introducing a PLS-SEM methodology to clarify simultaneous interactions. According to the results, the Global Innovation Index is influenced positively by the Human Development Index, while the Global Innovation Index has a positive effect on Global Competitiveness Index. Moreover, the Global Innovation Index played a mediating role between HDI and GCI. In other words, investing in human development activities does not directly bring about success on global competitiveness to countries that want to increase competitiveness; they should pay attention to innovativeness of the economies. These findings indicate that in order to gain competitive advantages, countries should improve their innovative capability without compromising human capital.

Even though this study makes valuable contributions to the literature, it has several limitations. First of all, only the countries placed in these indices were included in the analysis. Secondly, the data of 2015 were examined because of their currency, but past years were not included. Finally, the PLS-SEM methodology has its own restrictions. Although these limitations are acknowledged, research findings provide a basis for future research. For instance, sub-indices of main indices can be added into the model to see the interactions between constructs. Furthermore, the model may be validated by conducting analysis of the data for each accessible year. Additionally, Hoftsede's cultural dimensions may be added to the model as a moderator.

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