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Research Article

Philippine Ranking in Selected Global Indices: A Neural Perceptron Analysis

Jesus Juevesano[1], Adrian Tamayo[2*], Venus Ortuyo-Alod[3], Hamlet Lerios[4] and Robert Mutia[5]

[1]Lead Investigator, Faculty, Bukidnon State University, Philippines.
[2]Faculty, University of Mindanao, Master in Public Safety Administration CL 2022-24, Philippine Public Safety College, Public Relations Chief, Mindanao Development Authority, Philippines.
[3]PLtCol Venus Ortuyo-Alod, Deputy for Operations, Davao del Sur Provincial Police Office, Master in Public Safety Administration CL 2022-24, Philippine Public Safety College, Philippines.
[4]PLtCol Hamlet Lerios, Chief of Police, Digos City Police Station, Master in Public Safety Administration CL 2022-24, Philippine Public Safety College, Philippines.
[5]Jail Chief Inspector, Bureau of Jail Management and Penology, Master in Public Safety Administration CL 2021-23, Philippine Public Safety College, Ph.D. Candidate, De La Salle Araneta University, Philippines.
[*]Corresponding Author Email: a_tamayo@umindanao.edu.ph

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Abstract: This study measured the relative ranking of the Philippines in selected global indices from 2006-2021. The global indices include Democracy Index (DI), Corruption Perception Index (CPI), Global Innovation Index (GII), Security Threat Index (STI), Uneven Development Index (UDI), Public Service Index (PSI), Global Peace Index (GPI) and the Business Freedom Index (BFI). Employing the Kendall Tau rank correlation, the Democracy Index (DI), Security Threat Index (STI) are the most common indices that have association with all other variables. The Corruption Perception Index and Public Service Index also maintain multiple correlations with other variables. However, the significant association does not speak of causality, hence the Artificial Neural Network (ANN) was used. The ANN was chosen because of its strength in showing relationships of variables without the strictures of linear relationship. The ANN mimics the workings of the brain with the neural nodes and synaptic weights that influence the brain processing. The activation function was employed following a sigmoid non-linear system. Testing and training were found to be fast and qualified for a good model fit. The neural system representing the neural nodes of DI, CPI, GII, PSI, BFI and STI reveal positive synaptic weights for Uneven Development Index (UDI). An importance analysis under the feed forward network reveals that Global Peace Index (GPI), Security Threat Index (STI), and Public Service Index (PSI) are the top three global index that carry high weight values on the Uneven Development Index in the Philippines. This means that peace, security and good governance are the tri-pillar of the country's ascent in the global ranking.
Keywords: Global index, Philippine ranking, Artificial Neural Network, Peace and Security.

Introduction

The Philippines, as a democratic state, is one of the nations that is ranked along with other nations of the world in global indices. The ranking provides an overview of how the nation fared in the chosen metric of comparison to help multilateral organizations, private investors, aid and donor agencies, and tourists decide with respect to their individual or collective intentions. The matter of good governance, in some instance, is computed in a metric to show how good the good governance is in a country (Gera, 2011, Triguswinri, 2021) relative to all other countries. A diagnostics of governance

link them with corruption bias (Tadem, 2012) impedes the improvement of corruption perception ranking of the Philippines in the global ranking. When corruption perception worsens, it would affect the attractiveness of the investors to pour in capital in a country. When investments come to a trickle, the domestic economy slows down, putting to a halt some of significant production activities, forcing employers to lay-off workers, and eventually leading to local instability as there are more unemployed, rising prices, and the potential of domestic violence to erupt.

It is the habit of big organizations to compare countries in the world to show how an advance country works, both internal and foreign, and reveal the conditions in the fragile and weak countries which may either lead to policy reforms or denial of support unless structural changes are implemented. This was the finding of Hazelkorn (2009) when institutions are compared, much more the same would happen to countries when compared with their neighbors. On the light of the foregoing, this study was conducted to determine the Philippine ranking in selected global indices, and determine which of the metrics make impact on the inequality situation that is prevalent in the Philippines.

Method

The study followed a quantitative design to determine the correlation of the global indices in the performance of the Philippines in the last fifteen years. The data were extracted from various online reports, from period 2006 to 2021 of the following global indices. The Democracy Index Report for the Global Democracy Index published by the Economist Intelligence Unit (EIU) which is the research division of the Economist Group, a UK-based company[1].

The Corruption Perception Index (CPI) which is produced by Transparency International[2], measures the levels of corruption of a country and compares it with 180 countries and territories of the world. In 2007, Professor Soumitra of INSEAD or Institut Européen d'Administration des Affaires, a business school with campuses in Europe, Asia, Middle East and North America, published the Global Innovation Index (GII)[3] to obtain the measurement that could capture the innovation of the society. The Security Threat Index was obtained from the Global Economy database which gather data from official sources including World Bank, International Monetary Fund, the United Nations and the World Economic Forum[4].

Similarly, the Uneven Development Index (UDI), the Public Service Index (PSI) were obtained from the Global Economy database. The UDI measures the inequality that occurs in the nation irrelevant of the economic situation of the country, while the PSI determines the presence of basic state functions in serving the people that include provision of fundamental social services like health, education, water and sanitation, energy and transportation, and internet connectivity.

The Vision of Humanity produces the Global Peace Index (GPI) which is an index to measure the peacefulness of countries by looking at the level of societal safety and security, extent of on-going domestic and international conflict, and the degree of militarization[5].

The data for the Business Freedom Index were taken from the Heritage Foundation and the Wall Street Journal to determine the economic freedom in the nations of the world. The chosen indices for the Philippine ranking were statistically processed using the Kendall tau test for rank correlation. This would allow the determination whether the Philippine ranking in a particular index finds its way in another Philippine ranking index. Kendall tau measures the ordinal association between measured quantities.

[1] Democracy Index. https://www.eiu.com/n/
[2] Transparency International. https://www.transparency.org/en/about
[3] Global Innovation Index. https://www.globalinnovationindex.org/about-gii
[4] The Global Economy. https://www.theglobaleconomy.com/Philippines/security_threats_index/
[5] Vision of Humanity. Global Peace Index. https://www.visionofhumanity.org/maps/#/

The Kendall tau is denoted by the equation

$$\tau = \frac{\eta_c - \eta_d}{\eta(n-1)/2}$$

While an association is determined using the Kendall tau test of rank correlation it is not enough for lack of causality analysis. On this, the non-linear artificial neural network (ANN) of the multilayer perceptron layer in a feed forward unsupervised machine learning was used.

The ANN is a computational model that follows the function of human brain (Krogh, 2008) where large number of processors called nodes are linked by weighted connections working like neurons and fires electrical circuits following a synaptic function.

The mathematical equation for the ANN is given as

$$v_k = \sum_{j=1}^{p} w_{kj} x_j$$

following the Dongare *et al.*, (2012) formulation. To acknowledge the nonlinearity of the networks, the sigmoid transfer function was employed.

Findings and Analysis

As presented in the panel below, the Democracy Index (DI) is a description of the conditions of democracy of independent countries in the world. Started in 2006 by The Economist Intelligence Unit (EIU) Limited, it measures the global democracy situation as evaluated in the areas of electoral process and pluralism, functioning government, political participation, political culture and civil liberties.

In comparison with 165 states, Philippines oscillated ranking from 55 to 75, with observed improvement in democracy index ranking in the last 6 years (See figure a).

Figure b presented the Philippine performance, since 2006, the Corruption Perception Index (CPI) produced by transparency international to curb injustice and corruption through promotion of transparency, accountability, and integrity.

It is aimed at accountability of those who are in authority, as the CPI draws the line of understanding corruption, as opposed to all other descriptions, it defined corruption as the abuse of those who are entrusted with power, violating the tryst between the governed and the government in the excesses of the latter.

As shown in figure b, Philippines can barely move out from the worse ranking, ranging from 85 to rank 139, the higher the rank the more corrupt a country is relative to other countries being compared.

Admittedly and quite impressively, Philippine position in the CPI ranking points to a promising government effort of subscribing to the transparency programs in 2013 to 2014, but it gets worse in the subsequent years then after.

The other global index used in the study is the Global Innovation Index (GII) which is an annual ranking of countries given their capacity for success and innovation. Started in 2007, it sizes up the countries innovation, advances in science, technology development and dissemination, and improvement for sustainable development. The GII has been referred to by governments of many countries in determining their relative advances in science and innovation, which are reflections of the soundness of their educational system, policy for innovation, and overall technological performance.

In the last 15 years, Philippines showcased a rather persistent improvement in this index; ranking oscillates between 53 to 100 relative to 130 countries.

The Philippines global position in the metric of Global Peace Index (GPI), produced by the Institute for Economics and Peace, shows the relative position of the country relative to the level of peacefulness of 163 countries in the world. As shown in figure d, Philippines experienced a decreasing peaceful situation in 15 years, vacillating between 100th to 141, then marginal improvement in the most recent six years.

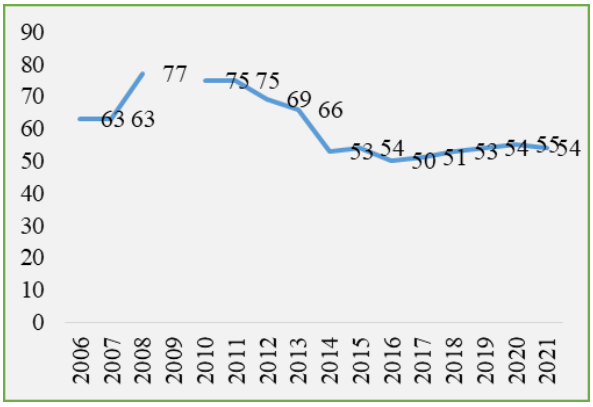

Figure a. Democracy Index, Philippine ranking

Figure b. Corruption Perception Index, Philippine ranking

Figure c. Global Innovation Index, Philippine ranking

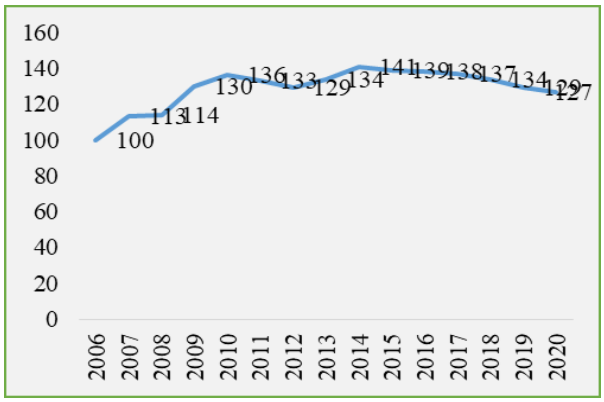

Figure d. Global Peace Index, Philippine ranking

Panel 1 [fig a] Democracy index ranking of Philippines seen to improve from 2006-2021; [fig b] Corruption Perception Index of the Philippines takes marginal improvement in 16 years, 2006-2021; [fig c] Global Innovation Index oscillated over the years; [fig d] Global Peace Index ranking of Philippines declined in last 16 years.

Meantime, the Philippine security threats had worsened in the last 15 years given its susceptibility to violation of security owing to circumstance, action capability or situation that causes harm.

From rank 19, the country went down to rank 4 and maintained it over the most recent four years. Please see figure e. In addition, the uneven development also worsened in the last 14 years but made a significant improvement in the year 2020 making it to top 85 from the previous 104.

The Philippine Public Service Index (PSI) is quite impressive. Though staggers in its improvement, the country landed a better notch in the last seven years in the global ranking. Distor and Khaltar (2012) enumerated the motivating factors like internal capacity, rewards for good performance and compliance with the national government drive the local governments in the Philippines in achieving public service efficiency.

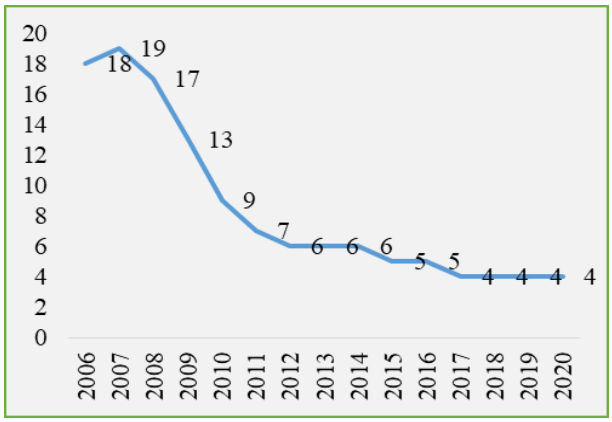

Figure e. Security threats index, Philippine ranking

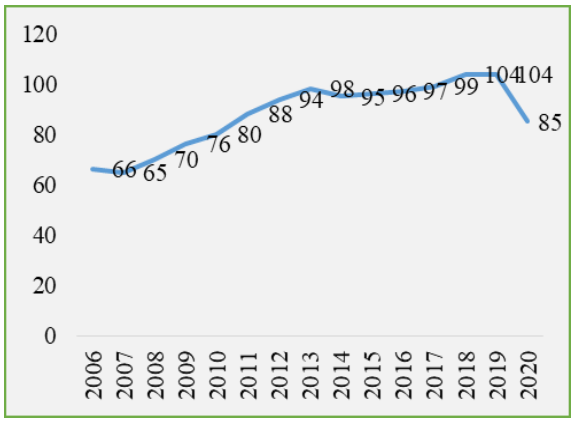

Figure f. Uneven development index, Philippine ranking

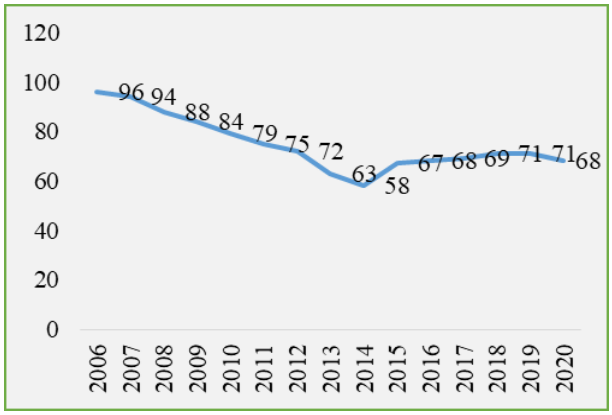

Figure g. Public Service Index, Philippine ranking

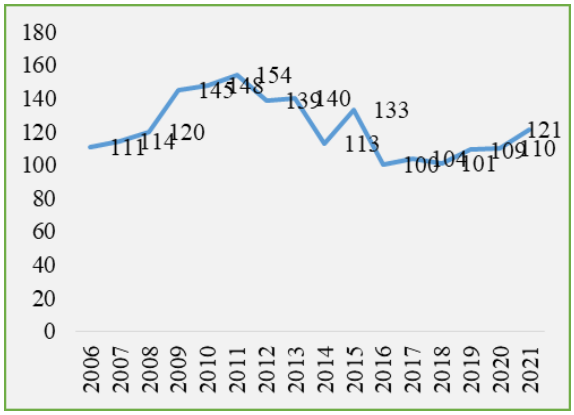

Figure h. Business Freedom Index, Philippine ranking

Panel 2 [fig e] Security threats is prevalent in Philippines and gets worse by the year; [fig f] Uneven development ranking of Philippines is seen to have been improving in the last 15 years; [fig g] Public service index; [fig h] Business Freedom Index had been erratic since 2006 to 2021.

The Philippine business freedom index is found to show erratic ranking; which pattern is barely recognizable in the medium term. This is representative of the kind of investor confidence to the government's ability to regulate the opening, sustaining and closing of the businesses in the country. Khan *et al.*, (2019) relate business freedom with the use of remittances to private investment, in a micro level. They pointed out that the effective use of remittance takes optimal value when converted into packets of private investments. This takes a good logic. When taken in general, this means the ability of the households in the economy to propel micro economic activities leading to propulsion that forces the country forward, economically.

As presented in table 1, the Democracy Index (DI) is correlated with Corruption Perception Index (CPI), Security Threats Index (STI), Uneven Development Index (UDI), Public Service Index (PSI), Global Peace Index (GPI), and the Business Freedom Index (BFI). Intuitively, the democracy ranking of the county maintains a positive but moderate correlation (50%). The same positive correlation was observed with Security Threat Index (STI) and Democracy Index (DI) with 54% degree of association. Democracy Index (DI) is inversely correlated with Uneven Development Index (UDI) with a moderate correlation (-49%). This is expected as positive democracy is the foundation of addressing inequality in economic position of any country. Countries lacking democratic practices tend to be less flexible in responding to international changes (Freedman, 2006) and negatively impacts local participation to the well-being of the people (McIntyre-Mills, 2010). DI is positively correlated with Public Service Index (PSI) with a moderate correlation (69%) which is

an indicative that improvement in public services is associated with improvement in democratic tools of a country.

Democracy which evokes liberty in pursuit of the values takes into account the manner by which the government and its various instruments carry the ideals of the nation (Hamilton, 2005) to ensure that the people would be able to protect themselves and be defended by the government in the pursuit of their well-being. The Global Peace Index (GPI) is inversely associated with DI (-43%). This is counterintuitive knowing that improvement in democratic institutions lead to improvement in the peace situation, which came out to be the reverse in relation to the Philippines' movement in ranking in the two mentioned variables. This is quite intriguing. The restoration of democracy to the Philippines in 1986 did not effectively usher the peace owing to the ballooning debts, persistent poverty (Ringuet and Estrada, 2003) and the continuing failure in peace deals which set the downtrend trajectory of the Philippines (Teehankee and Calimbahin, 2020) and the many attempts to topple the government since its liberation from the American colonisers (Kreuzer, 2005).

The Business Freedom Index (BFI) maintains a moderate correlation with DI (64%) which reveals that the ease of opening a business, operating and closing a business is associated with the reliability on electoral process and pluralism civil liberties, and functionalities of governments which are the metrics measured in the democracy index. The Corruption Perception Index (CPI) is positively correlated with DI (50%), inversely correlated with GII (40%), positively associated with STI (35%), positively correlated with PSI (61%). Thus it may seem that improvements in global innovation, which is a ranking of innovation ecosystem, relates to improvement in corruption situation because efforts to curb corruption leads to improving level of trust in the mechanisms of the market and instruments of the government making the impression that state actions and sanctions are impartial and legal (Anokhin and Schulze, 2009).

The Global Innovation Index (GII) which measures the local situation of abilities, capacities and success for innovation is found to be associated with corruption, and as naturally noted, only when the instruments of the government and the market are reliable shall the innovators, scientists and thinkers get to involve and produce new ideas and technologies that can prompt forward the ranking of the country.

The Uneven Development Index (UDI) looks at the inequality within the domestic economy regardless of the actual economic performance of the economy. It is important to consider this metric given that an impression of inequality may serve as an ember that will cause local tension and grievance that will escalate to rebelling against the established government of a country.

Table 1. Correlation of Variables

Variables	DI	CPI	GII	STI	UDI	PSI	GPI	BFI
DI	1.0000	0.5002***	0.0396^{ns}	0.5392**	-0.4888**	0.6858***	-0.4343**	0.6375**
CPI	0.5002***	1.0000	-0.3967**	0.3504***	-0.4976^{ns}	0.6058***	-0.4904**	0.2667^{ns}
GII	0.0396 ^{ns}	-0.3967 **	1.0000	0.2123^{ns}	-0.0580^{ns}	-0.1456^{ns}	0.2621^{ns}	0.1604^{ns}
STI	0.5392**	0.3504**	0.2123^{ns}	1.0000	-0.7948***	0.5459***	-0.3336**	0.4305**
UDI	-0.4888**	-0.4976 ^{ns}	-0.0580^{ns}	-0.7948***	1.0000	-0.5314***	0.4058**	-0.4019^{ns}
PSI	0.6858**	0.6058***	-0.1456^{ns}	0.5459***	-0.5314***	1.0000	-0.6117^{ns}	0.3173^{ns}
GPI	-0.4343**	-0.4904**	0.2621^{ns}	-0.3336*	0.4058**	-0.6116***	1.0000	-0.2404^{ns}
BFI	0.6375***	0.2667 ^{ns}	0.1604^{ns}	0.4305**	-0.4019^{ns}	0.3173^{ns}	-0.2404^{ns}	1.0000
*** significant at 1% margin of error; ** significant at 5% margin of error; * significant at 10% margin of error ns-not significant								

In the Philippines, the UDI is inversely associated with democracy (49%), with Security Threat Index (79%), with public service (53%), while it is positively correlated with global peace.

The considerable association between security threats only points to the important role of addressing first hand potential threats that imperil the safety of the people of the nation. When the benefits of addressing security threats fortify the public service, it is of interesting notice that the improvement in conditions of security threat will have on the conditions of the community. In the words of Morgan and Sayer (2009) that the dividends of effective actual and positive developments slice the compactness of uneven development.

The Public Service Index (PSI) is positively associated with democracy (43%), corruption perception (61%), security threat (54%), while it is negatively related with the uneven development (53%).

Perry and Buckwalter (2010) argued in their study that the heightening professionalization as expected in a more dynamic economy will tend to spiral out from security threats towards employment of science and technology, data sciences, in ensuring effective governance and public administration. It is the very nature of public service that makes it more complex which should be handled and managed with the sciences, thereby curbing threats, leading to improvement in systems and public management (Osborne and Brown, 2012).

The Global Peace Index (GPI) which measures the relative peacefulness of countries is negatively associated with democracy (43%), corruption (49%), security threat (33%), and the public service (61%). However, it is positively correlated with uneven development (41%).

This takes considerable viewpoint. An improvement in the county's democracy improves the peacefulness of the country, but the Philippine's case is different.

An improvement in democracy leads to decline in peacefulness. This again can be attributed to the persistent insurgencies that happen in the Philippines after obtaining its freedom from the Americans (Ringuet and Estrada, 2003) and the continuing levels of violence from non-state actors (Zulueta Fülscher, 2018) which affected the Philippines consolidation of its democracy and improvement in its public service and the expected welfare conditions of its people.

The Business Freedom Index (BFI) which is a measurement of the country's efficiency in government regulation of business in relation to its opening, operating and even closing down is positively correlated with democracy index (64%) and security threat index (43%).

It is intuitive to find that democracy moves in the same direction as the business freedom because the instrumentalities of a functioning democracy are relevant in decision-making of business establishments.

However, a similar direction for security threat and business freedom is a flipside. Security threat topples the credibility of the government and business, and yet they move into similar direction.

Perhaps the paper of Tinnefeld (2009) which connects the freedom and security leading to addressing international terrorism may be able to provide context on the interest of businesses to nations that support efforts to address global terrorism. In the current global village, businesses have branches all over the world, and so their interest is not confined in a single country's state of business regulation and security, but across all other countries where they operate.

After establishing the correlation of the variables, the causality technique was pursued using the artificial neural network analysis.

Table 2. Network information of variables for Neural Network Analysis

Parameters	Information on covariates		Variables
Input Layer	Covariates	1	DI
		2	CPI
		3	GII
		4	PSI
		5	GPI
		6	BFI
		7	STI
	Number of Units		7
	Rescaling Method for Covariates		Standardized
Hidden Layer (s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1a		1
	Activation Function		Sigmoid
Output Layer	Dependent Variables		UDI
	Number of Units		Standardized
	Rescaling Method for Scale Dependents		1
	Activation Function		Identify
	Error Function		Sum of Squares
a. Excluding the bias unit			

As presented above, seven variables were chosen to describe the Philippine ranking in the global indices. These variables such as democracy index, corruption perception index, global innovation index, public service index, global peace index, business freedom index, and the security threat index were factored in as input variables composing the input layer.

The output layer employed was the uneven development index which represent the condition of economic inequality beyond the economic performance of the nation. The uneven development index points at the condition of how severe or less the situation of inequality in the country given the material and natural resources, and the social mechanism that allows the people to benefit from the redistributive capacity of the state in allocating wealth.

Table 3 presents the summary of the neural model. As noted, the training and testing parameters cover the measurement of errors where the SSE takes 0.8497, while the relative error for the training is 0.1416. The stopping rule for the machine learning include 1 consecutive step with zero decrease in error. This indicate a fast training for the data.

Table 3. Model Summary

Dimension	Metric	Values
Training	Sum of Squares Error	0.8497
	Relative Error	0.1416
	Stopping Rule Used	1 consecutive step (s) with no decrease in error
	Training Time	0:00:00.00
Testing	Sum of Squares Error	2.295892
	Relative Error	Can't be computed
Dependent Variable: UDI		

The testing parameter include an SSE of 2.295892, while the relative error cannot be computed. For this machine learning technique, the output layer which constitutes the dependent variable is Uneven Development Index (UDI).

As presented in figure i, the neural network resembles the brain function where it stimulates the interconnected process units that represent neurons and are arranged in layers. These layers are called input layers.

This paper employed a feed forward neural network. In this model, the artificial neurons are arranged as layers, while their signals are sent forward, and the errors are propagated backwards. The intention of back propagation is to reduce the error term towards ANN learning the training data.

Dongare *et al.,* (2012) describe that the neural network receives the inputs through the neurons in the input layer, while the output receives the signals of the output layer. The training starts with the random weights, and error adjustment takes place. The network will be more of a multi-layer perceptron owing to the multi-layer network that contains a minimum of one hidden layer, on top of the input and output layers.

As presented below, Democracy Index (DI) has synaptic weight of 0.145, Corruption Perception Index (CPI) with 0.145, while the Global Innovation Index (GII) with 0.018, Public Service Index (PSI) 0.873, Business Freedom Index (BFI) with 0.275 and Security Threat Index (STI) with 1.021. The Global Peace Index (GPI) contributes -0.957 to the overall weight in addition to the input layer bias with -0.691, in predicting the Uneven Development Index (UDI).

The hidden layer contributes a synaptic weight to the UDI with -2.342, along with the output bias of 0.793. Thus, given the activation function,

$$v_k = \sum_{j=1}^{p} w_{kj} x_j$$

the total impulse effect of the indices on the uneven development will be is 0.134 in absolute terms.

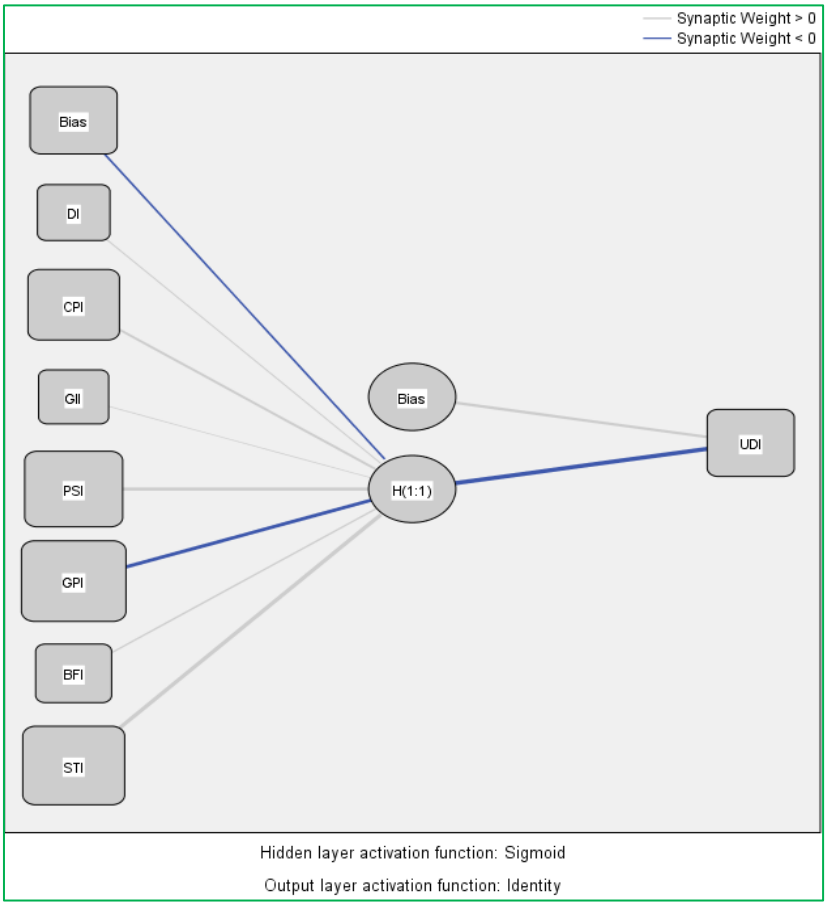

Figure [i]. Perceptual neural network showing the synaptic weight and hidden layer weight to the output layer, Uneven Development Index (UDI)

Taking the weight values of the input layer and feed forwarding them to the output layer UDI, the variable importance analysis can now be obtained after the training data following the back propagation.

As presented in table 4 which summarizes the indicated importance of the variables having influence on the UDI, it came out that the Global Peace Index (GPI, which measures the peacefulness of the country, can make significant improvement in the UDI.

The same goes for the Security Threat Index, whereby, an improvement in the Philippine ranking in this metric will lead to a leverage in the UDI thereby dousing chances of resentment of citizens against their government owing to widening gap between the rich and the poor, which Klare (1996) calls as global schisms and resonated in multiple security studies (Booth, 1991; 2004; Krause and Williams, 2018) which is also happening within the backyard of the Philippines.

The Public Service Index is also a robust ranking metric which can determine the uneven development metric of the Philippines. An improvement in the public services including government provision of health, water and sanitation, education, transportation, electricity and power, and in today's age, internet connectivity, will lead to stability of state, and also in the improvement in the UDI ranking of the country.

Liu and He (2019) lends support to this finding where they found that improvement in the soft services, that is, education and social services improves the rural-urban inequality.

The other parameters like corruption perception index (CPI), Business Freedom Index (BFI), Democracy Index (DI) and Global Innovation Index (GII) also reveal important stimulation in the state of inequality in the Philippines which serves as the main reference of the nation's ranking in the Uneven Development Index (UDI).

Table 4. Independent Variable Importance

Variables	Importance	Normalized Importance
GPI	0.2751	100.00
STI	0.2544	92.46
PSI	0.2236	81.29
CPI	0.1715	62.35
BFI	0.0500	18.17
DI	0.0221	8.05
GII	0.0031	1.12

Taking into account the neural analysis using feed forward network reveals that the important indices, where which the Philippines must hold in retrospect to address its global standing, are the country's peace, security and public service situations.

The country can improve its relative peacefulness by banking on its peace agreements and initiatives with the non-state actors including the Moro Islamic Liberation Front (Quimpo, 1999; Caballero and Torres, 2014), Moro National Liberation Front (Abubakar, 2004; Bacani, 2006; Chan, 2014), the NPA and other threat groups (Chalk, 2009; Santos, 2010) that disfigure the nation's peace position in the global arena.

Very clearly, the catapulting platforms of the Philippines in the global indices stand on the relative peacefulness, reduced vulnerability to security threats, and improvement in the public services more particularly on the social services, such that the inequality in the economy is improved, and well-being gets better.

Conclusion

On the light of the foregoing, the study reveals that the Philippine performance in the global indices does not fare well over the last 15 years, although some marginal improvements were noted in uneven development index (UDI), democracy index (DI), and global innovation index (GII). Democracy index (DI) and the Security Threat Index (STI) demonstrate multiple correlation with other global metrics except with the global innovation index.

However, the associational analysis does not speak of causation. Given the limitation of non-causality of the rank correlation test, the artificial neural network using a multilayer perceptron for a feed forward network was employed.

The neural network analysis found that the global standing of the Philippines in addressing uneven development can well be taken care of by the improvement in the Global Peace Index (GPI) ranking which denotes the country's state of peacefulness. The same can be expected if the Security Threat Index (STI) and Public Service Index gets better over time.

Therefore, it is proven that to improve the Philippines ranking in inequality, the peace, security and social services have to be improved. In this manner, the global position of the Philippines improves, business interest pours in, capital values improve, and consequently, levels of domestic well-being improve.

Conflicts of interest: The authors declare no conflicts of interest.

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