A NEW PERSPECTIVE IN COMPETITIVENESS OF NATIONS

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February 2006

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Abstract

In today's global world even a small organization has to compete on international level. In order to provide opportunities to realize a global competitive advantage, the executives and policy makers should be able to see the relative competitive position of their home country. However, currently developed indices to measure competitiveness generally include subjectivity especially in the specification of criterion weight and the assignment of the countries to different stages in terms of competition level. This precludes the efficient use of such indices. The aim of this paper is to explore whether a methodological transparency to measure the competitiveness of the countries can be provided to solve the subjectivity issue posed by the current aggregated indices. For this purpose, an Artificial Neural Network-based methodology is proposed to objectively cluster the countries into stages as well as to reveal the weight of the criteria that play the dominant role in each stage. Subsequently, a new composite index is proposed using the calculated weights.

Keywords: Ranking, Competitiveness, Artificial Neural Network

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1. Introduction

In today's globalised world, competitiveness has become a milestone of both advanced and developing countries. Because of recent pressures introduced by globalisation, it is important to have a model for the analysis of a country's competitive position in the international market, and not simply its internal measure of productivity. It is common knowledge that the marketplace is no longer restricted to a particular geographic location. A business can no longer expect competition only from neighboring businesses or from businesses within its own region. The marketplace is now global and even the smallest of organizations compete on an international level. In order to provide for the firms the necessary opportunities to survive and realize the global competitive advantage, it is primarily necessary to define the relative competitive position of their home country.

A nation's competitiveness can be viewed as a nation's relative competitive position in the international market among other nations of similar economic development. The capability of firms to survive and to have a competitiveness advantage in global markets depend, among other things, on the efficiency of the public institutions, the excellence of the educational, health and communication infrastructures as well as the political and economical stability structure of their home country. On the other hand, an outstanding macroeconomic environment alone cannot guarantee a high level of national competitive position unless firms create valuable goods and services with high level of productivity at micro level. Therefore the micro and macroeconomic characteristics of an economy jointly determine its level of productivity and competitiveness.

A nation's competitiveness is defined as the degree to which a nation can, under free and fair market conditions, produce goods and services that meet the standards of international markets while simultaneously expanding the real income of its citizens, thus improving their quality of live [1, 25]. It includes the set of institutions, policies, and factors that determine the level of productivity of a country [24].

Although many view competitiveness as synonym for productivity [21], these two related terms are in fact different. The productivity refers to the internal capability of an organization while competitiveness refers to the relative position of an organization against its competitors.

This paper addresses two major methodological issues concerning the construction of a composite indicator of national competitiveness. The first is the choice of weights to aggregate the underlying primitive data concerning the micro and macroeconomic factors. Most composite indicators currently used either take predetermined fixed weight values that are applied uniformly to all countries, or use subjective weights to different cluster of countries. These type of weights may bias measurement, and, hence inferences of relative measurement. The second issue is the specification of the stages of countries and understanding of the criteria that have the highest level of impact in the specification of the relative position of the countries in terms of competition. Again in most composite indicators, such as the ones developed by World Economic Forum (WEF), although the countries are clustered according to their different stages of competitiveness, this classification is rather subjective in nature or is solely based on income per capita and the threshold to separate one stage from the other does not reflect any objectivity. However, if the countries can be clustered taking into consideration their similarities with respect to different criteria, then it will be possible to reveal the important criteria underlying the competitiveness position of each stage, and consequently, of each country in a specific stage. Therefore it will be much easier to understand the internal dynamic of each stage and provide useful and objective guidelines to each country in their way to improve their relative position with respect to countries located in higher stages.

In the second part of this research, different indices developed and used by WEF to analyze the competitiveness of nations are summarized and the subjectivity in their weighting and clustering method is underlined. The third section introduces the proposed methodology to cluster the countries into stages and to reveal the weight of the criteria that play the dominant role in each stage. Finally a new composite index is proposed using the calculated weights and the results are compared with those of Global Competitiveness Index of WEF to specify whether the weight values adopted by WEF incorrectly penalize some countries and/or favor other countries since the resulting competitiveness index values and the subsequent ranking of countries are biased. Some useful guidelines are also provided to selected countries in their way of improving their position in terms of relative competitiveness. Finally conclusions and suggestions are given.

2. Assessing Countries' Competitiveness Indexes: Current State of the Art

Although there are many researches on competitiveness measurements, they generally focus on firm [11, 13, 18, 19, 20, 21] or industry level [1, 2] and very few studies have attempted to make a comparison of multi-country competitiveness [18, 28, 25,24].

Each year organizations, such as the WEF and the Institute for Management Development (IMD) [30], publish rankings of national competitiveness among countries. These rankings serve as benchmarks for national policy makers and interested parties to judge the relative success of their country in achieving the competitiveness criteria represented by the corresponding competitiveness index.

IMD, initially jointly with WEF, produces comparisons of nations' competitiveness via the annual publication of the World Competitiveness Yearbook since 1982. It develops a competitiveness score of selected OECD countries and newly industrialized countries based on political and socio-economic indicators. It provides a competitiveness score for each country by synthesizing all collected information into eight major factors: 1) domestic economy, 2) internationalization, 3) government, 4) finance, 5) infrastructure, 6) management, 7) science and technology, and 8) people.

Each of these factors is represented by at least 30-50 sub-criteria among which inter-correlation is difficult to avoid. Countries are given scores in each of these eight factors, based on both quantitative and survey data, and then a weighted average is taken to produce the Overall Competitiveness Index. As a result, the selected countries are evaluated on approximately 350 political, social, and economic indicators.

Oral and Chabchoub, after detailed mathematical programming modeling by sub-factor levels, showed that the methodology used in World Competitiveness Yearbook is hard to guess and suggest the need of other statistical or other mathematical programming techniques [20].

For the last quarter-century WEF leads in the evaluation of the competitiveness of nations through its publication, The Global Competitiveness Report, but the methodology that it used to assess national competitiveness has evolved over time.

WEF uses three competitiveness indexes in order to analyze the competitiveness level from two different perspectives. Growth Competitiveness Index (GCI) developed by McArthur and Sachs [15], and Blanke and Lopez-Claros [2], analyze the competitiveness from aggregated macroeconomic indicators' perspective while Business Competitiveness Index (BCI) [23] investigates the company-specific factors that lead to improved efficiency and productivity indicators at the micro perspective. In fact, in 2002, BCI was called the Microeconomic Competitiveness Index. As is well known, GCI makes an evaluation based on critical and mostly macroeconomic environmental factors that influence the sustained economic growth over the medium to long term. Porter's BCI, however, with a focus on company-specific factors, is complementary to GCI. Recently, a Global Competitiveness Index, which is a synthesis of GCI and BCI, is also provided.

2.1 Growth Competitiveness Index

Growth Competitiveness Index is composed of three factor groups, being all accepted as critical to economic growth. The detail configuration of GCI is given in Figure 1.

Insert Figure 1 here.

GCI uses a combination of hard data and data from the WEF's Executive Opinion Survey, with responses ranging from 1 to 7. In order to standardize, the hard data is also converted to the 1-to-7 scale.

Due to the fact that the importance given to the role of technology differs between the countries depending on their stage of development, in estimating GCI, the countries are divided in two groups: the "core" economies where the technological innovation is critical for growth and the "non-core" economies that are still growing by adopting technology developed abroad. The separation is based on the threshold of 15 patents per million populations.

For the core innovators (with more than 15 patents) the GCI is calculated as:

$$\text{Core GCI} = \tfrac{1}{2}\,\underset{\text{index}}{\text{technology}} + \tfrac{1}{4}\,\underset{\text{index}}{\text{public institution}} + \tfrac{1}{4}\,\underset{\text{index}}{\text{macroeconomic environment}}$$

For the non-core economies, however, the GCI is calculated as:

$$\text{Non-core GCI} = \tfrac{1}{3}\,\underset{\text{index}}{\text{technology}} + \tfrac{1}{3}\,\underset{\text{index}}{\text{public institution}} + \tfrac{1}{3}\,\underset{\text{index}}{\text{macroeconomic environment}}$$

GCI aims to rank the countries and also track the changes in the ranks over time.

2.2 Business Competitiveness Index

Business Competitiveness Index explores the underpinnings of a nation's prosperity, measured by its level of GDP per capita. The focus is on whether current prosperity is sustainable. BCI accounts for 81% of variation across countries in the level of GDP per capita. BCI accepts that true competitiveness is measured by productivity. A nation's standard of living is determined by the productivity of its economy, which is measured by the value of goods and services produced per unit of the nation's human, capital, and natural resources. Figure 2 shows the configuration of BCI.

Insert Figure 2 here.

Although stable political, legal, and social institutions and good fiscal and monetary policies create the potential to create wealth, they do not themselves create wealth. Wealth is created in the microeconomic level of the economy and unless these microeconomic capabilities improve, macroeconomic, political, legal and social reforms will not be sufficient [23].

As nations develop, they progress in terms of their competitive advantages and modes of competing. In the *Factor-Driven stage*, basic factors such as low-cost labor and unprocessed natural resources are the dominant sources of competitive advantage. In this stage, companies compete on price and have limited role in the value chain. For low-income countries at the Factor-Driven stage of development, the ability to move beyond competing on cheap labor and natural resources is the essential challenge. Those countries score low on most measures but especially on infrastructure, educational quality, capital access, cluster development and measures related to technology and innovation. In these countries priority should be given to upgrading the quality of infrastructure and opening competition.

In the *Investment-Driven stage*, efficiency in producing standard products and services becomes the dominant sources of competitive advantage. Heavy investment in efficiency structure, strong investment incentives and better access to capital allow major improvement in productivity. Improving production process sophistication is the most important corporate priority. Companies must also begin to increase the professionalism of management, create the capacity for technology absorption, overcome their dependence on exports to a few, advanced foreign markets. Middle income countries score low especially on infrastructure, the legal and regulatory efficiency and transparency and the task is to move from Factor-Driven stage to Investment-Driven stage. Improving university-industry research collaboration and the quality of research institutions as well as the quality of the judicial system becomes an important success factor.

Finally, in the *Innovation-Driven stage*, the ability to produce innovative products and services using the most advanced methods becomes the dominant source of competitive advantage. To succeed in a high-income economy, it is necessary to move to the Innovation-Driven stage. Deep cluster development, the quality of the regulatory environment, the sophistication of demand conditions and of local fiscal market, the quality of management education are important distinguishing factors for most successful high-income economies.

2.3 Global Competitiveness Index

Recently WEF introduced Global Competitiveness Index to rank the countries. While the GCI refers to macroeconomic determinants of productivity, BCI captures the microeconomic components of it. Additionally, while GCI is supposed to capture the “dynamic” determinants of productivity, BCI captures the “static” determinants. In reality, the macroeconomic and microeconomic determinants of competitiveness cannot be separated. The ability of firms to succeed depends, among other things, on the efficiency of the public institutions, the excellence of the education system, and the overall macroeconomic stability of the country in which they operate. Productivity has both static and dynamic implication for a country’s standard of living. Only by reinforcing each other can the micro and macroeconomic characteristics of an economy jointly determine its level of productivity and competitiveness. That is why, in 2004 WEF report, a new index is developed with the goal of unifying the two indexes; namely GCI and BCI, and replaces them in the Global Competitiveness Index.

This new index is based on three principles: 1) the determinants of competitiveness are complex and the competitiveness is composed of twelve pillars. 2) The economic development is a dynamic process of successive improvement, i.e. it evolves in stages. 3) As economies develop, they move from one stage to the next in a smooth fashion

According to the first principle, the twelve pillars of economic competitiveness can be stated as in Table 1.

Insert Table 1 here.

These twelve pillars are, in fact, related to each other and tend to reinforce each other. For example, innovation (12^{th} pillar) cannot be performed in a country with no human capital (5^{th} pillar) and will never take place in economies with inefficient markets (6^{th}, 7^{th} and 8^{th} pillars), without infrastructures (2^{nd} pillar) or nations at wars (4^{th} pillar).

On the other hand, according to the second principle of Global Competitiveness Index, the countries belong to one of three stages. Each of the twelve pillars has different weights for each stages of development. In the most basic stage, called *factor-driven stage*, firms compete in price and take advantage of cheap labor and/or unprocessed natural resources. In the second stage, called *efficiency-driven stage*, efficient production becomes the main source of competitiveness. Finally, in the *innovation-driven* stage, successful economies can no longer compete in price or even quality and have to produce innovative products and practices using the most advanced methods of production and organization. The pillars that are important for the factor-driven stage are called *basic requirements* and include institutions (1^{st} pillar), physical infrastructure (2^{nd} pillar), basic human capital (first part of the 5^{th} pillar), macroeconomic stability (3^{rd} pillar), and personal security (4^{th} pillar). The pillars that are more important in the efficiency-driven stage are called *efficiency enhancers* and include goods market efficiency (6^{th} pillar), labor market efficiency (7^{th} pillar), financial market efficiency (8^{th} pillar), advanced human capital (second part of the 5th pillar), technological readiness (9th pillar), and openness/market size(10th pillar). Finally, the pillars that are more important in the innovation-driven stage are called *innovation and sophistication factors* include business sophistication and innovation (11th and 12th pillars respectively). As a result, in the computation of the global competitiveness index depending on the stage to which the country belongs, the three group of criteria; namely; *basic requirements, efficiency enhancers* and *innovation and sophistication factors,* are weighted differently (see Table 2) and the weighted average of these three groups is calculated.

Insert Table 2 here.

In the allocation of countries to the stages, the following criteria are taken into account:

1) If the country's GDP per capita is below US$2,000 or the fraction of its exports in the form of primary goods is above 70%, the country belongs to the factor-driven stage.
2) If a country has a per capita income between US$3,000 and $9,000 and does not export more than 70% in primary goods, it belongs to the second stage.
3) If a country has more than US$17,000 per capita income and less than 70% of the exports in primary goods, it belongs to the third stage.
4) Countries with income per capita between US$2,000 and 3,000 are said to be in transition from stage 1 to stage 2.
5) Countries with income per capita between US$9,000 and 17,000 are said to be in transition between stages 2 and 3.

Similarly to GCI and BCI, both hard data as well as survey data collected by the WEF are used in the calculation of the Global Competitiveness Index. These data are combined to estimate the 12 pillars of economic development. The index is calculated for 104 countries and the United States is found to be ranked as at top while the least competitive country of the world is Angola, followed by Chad, Ethiopia, Zimbabwe, and Mozambique.

As can be seen in all the above-given indices, although the weights given to different criteria is different for countries at different stages of development, the specification of these weights are subjective in nature, at least there is no information about the way they are specified. Similarly, the assignment of the countries to different clusters at different stages of development is either arbitrary or based on their income per capita level and the threshold values to separate each stage again show subjectivity.

3. The Proposed Methodology

The aim of this research is, initially, to provide an objective clustering of the countries according to their similarity to their values in different criteria.

Secondly, an objective weighting procedure is proposed. In fact, as was also mentioned in the earlier sections, the indexes used by WEF are generally composed of many criteria and each is given different weights according to the stage of the development of the country. However, the way of the specification of these weights is not explicitly given. For example, during the calculation of the Global Competitiveness Index, 177 criteria belonging to basic requirements, efficiency enhancers and innovation and sophistication factors are used. All those groups of criteria, however, are given different weights according to whether the country belongs to factor-driven stage, efficiency-driven stage or innovation-driven stage. Although such a diversification may be important, the way of the specification of the weights for each group as well as the authorities who specify them is not explicit. In this study, Artificial Neural Network (ANN) is used to specify the weights of different criteria in each stage. The criteria that play the dominant role in each stage are revealed based on these weights.

Finally, a new composite index is proposed for the ranking of the countries which is the weighted average of the indicators but taking as weights the ones revealed through ANN. As a result, the evaluation of the countries in terms of their competitiveness level is tried to be based on objective measurements. In the final step, the weights of the criteria for each stage are used to specify the ranking of the countries. Figure 3 gives the detailed flowchart of the proposed methodology.

Insert Figure 3 here.

The proposed methodology is applied to specify how the 103 countries evaluated by WEF in 2004 using Global Competitiveness Index can be clustered based on their competitiveness level. All of the countries evaluated by WEF, except Hong Kong are included in the analysis. The latter is left out of the scope of the research due to the inconsistencies in its data. The main reason of this is probably due Hong Kong which became special administrative region of China on 1 July 1997.

As far as the criteria are concerned, in addition to 177 criteria used by WEF to compute Global Competitiveness Index, the military expenditures are also considered as a criterion in the evaluation of competitiveness levels. The reason of including the military expenditures is that Ulengin et al. stated that military power is one of the most important criteria that affect the power of countries [25]. They showed that there is a significant relation between World Competitiveness Index and the economic, demographic and military power of countries.

3.1. Classification of Countries through Cluster Analysis

In the first part of this research, based on similarity of characteristics, the countries are grouped. Cluster analysis, which is in fact a multivariate statistical technique, is used for this purpose.

3.1.1. Cluster Analysis

Cluster Analysis involves grouping similar objects into mutually exclusive subsets referred as clusters [8]. The cluster definition problem is NP-complete, so an optimum does not exist. A number of heuristic methods are built for this purpose including agglomerative techniques the mostly widely known and used in such procedures. All hierarchical agglomerative heuristics begin with **n** clusters where **n,** is the number of observations. Then, the two most similar clusters are combined to form **n-1** clusters. On the next iteration, **n-2** clusters are formed with the same logic and this process continues until one cluster remains. Only the rules used to merge clusters differ in the various hierarchical agglomerative heuristics.

Although all hierarchical methods successfully define clusters for compact and isolated data, they generally fail to accurately provide defined clusters for “messy” data. The major issue with all clustering techniques is how to select the number of clusters. Different clustering methods may lead to different clusters, and the differences are generally due to the inherent characteristics of the methodology used. In fact, there is no single methodology that can be recommended in selecting the most appropriate number of clusters and the most suitable clustering method. That is why cluster analysis is generally accepted to be more of an art than a science [16].

In order to improve the accuracy of the cluster analysis and to reduce the subjectivity that plays an important role in hierarchical clustering, the Self-Organizing Map (SOM) Neural Network is used as suggested by Mangiameli et al [14]. SOM is, thus, not taken as an alternative, but rather as a complementary analysis that follows hierarchical clustering. The focus is, on the improvement of accuracy in the assignment of observations to appropriate clusters, given that the number of clusters in the data is known. SOM's network learns to detect groups of similar input vectors in such a way that neurons physically close together in the neuron layer respond to a similar input vector [12].

SOM networks are used to separate outputs into categories. They are unsupervised networks; that is, they have no output value in the training pattern to which training can be compared. In most other network models, all neurons adjust their weights in response to a training presentation while in SOM, that is not the case. In this kind of network, the neurons compete for the privilege of learning. SOM networks have two layers, the input layer of N variables and a Kohonen layer. In the Kohonen layer, the neurons are configured to reduce the size of N input neuron in the input layer to two dimensions. Each neuron in the input layer is related to Kohonen layer. During training, the patterns are presented to the network, then propagated to the output layer and evaluated. The weight vector of each neuron in the Kohonen layer and the input vector is calculated using Euclidean distance. The neuron closest to the input vector is selected as the "winner". The network adjusts the weights to the output neurons in a neighborhood around the neuron. SOM networks work by clustering patterns based on their distance from each other, according to the predefined number of clusters [14].

3.1.2. Determining the Stages of Countries

In fact, the basic drawback of a study based solely on ranking is that the ordinal scale does not reflect the appropriate competitiveness level of a country (entity) relative to other countries (entities). The most accurate position of a country within the total configuration can only be determined after the grouping of countries showing similarities to the evaluated country in terms of competitiveness.

In this study, initially a hierarchical cluster analysis is used. The Ward hierarchical method, an agglomerative clustering technique, and the Squared Euclidean distance is selected as the most appropriate distance measure throughout the evaluations using MATLAB software [31]. In Ward's method, the distance is the ANOVA sum of squares between the two clusters summed over all variables [8].

As can be seen from the dendogram given in Figure 4, the 103 evaluated countries can be grouped into three clusters.

Insert Figure 4 here.

Then, the appropriate number of clusters resulting from the first stage was next used to carry out the same analysis using SOM and the MATLAB software. Since we ought to categorize the countries into three classes, there are three outputs in the study's configuration. This leads to a 3*1 matrix of the weight vector. The topology function used is "HEXTOP" which means that the neurons are arranged in hexagonal topology at Kohonen layer, while the distance function is "MANDIST" which means that the used distance function is Manhattan distance (city block distance). Training of a self-organizing map using Matlab is achieved through two steps: ordering phase and tuning phase. At ordering phase, ordering phase learning rate and neighborhood distance are decreased from ordering phase learning rate and maximum distance between two neurons to tuning phase learning rate and tuning phase neighborhood distance, respectively. Ordering phase lasts for a given number of steps. At tuning phase, learning rate is decreased much more slowly than ordering phase and the neighborhood distance stays constant [32]. In this study, ordering phase learning rate, ordering phase steps tuning phase learning rate are taken as 0.9, 1000, 0.02, respectively.

The countries corresponding to the resulting stages are summarized in Table 3.

Insert Table 3 here.

For each stage, Table 4 shows the mean, standard deviation and coefficient of variation (CV= σ/μ) of the resulting clusters for overall, basic requirement, efficiency enhancer and innovation and sophistication factors perspectives. As can be seen in Table 4, the countries assigned to the first stage have a low overall index (mean 3.4) and, as can be expected, their basic requirement index values are higher compared to their efficiency enhancer and innovation factor values. Those countries can be accepted as non-competitive countries, at the *factor-driven stage*. Finally, the average overall index value of the first stage is well below the global average (3.89). Among the countries in this stage Turkey can be given as an important example.

On the other hand, the countries belonging to the second stage, have a higher overall index value (mean: 4.06), basic requirements (mean: 3.54) as well as efficiency enhancer (mean: 3.54) and innovation and sophistication factors scores (mean: 3.24) when compared those of the 1st stage. However, their innovation and sophistication factors scores are relatively lower when compared to the others. These countries can be accepted to be competitive countries, at the *efficiency –driven stage.* It is interesting to note that China, accepted as one of the most promising country in terms of competitiveness, belongs to this category.

Finally, the countries assigned to the last stage have the highest scores concerning the overall index (mean: 4.73), basic requirements (mean: 5.63), efficiency enhancers (mean: 4.36), and innovation and sophistication factors (mean: 4.33) scores. In fact, their innovation and sophistication factors score is almost the same as their efficiency score and they can be accepted as highly competitive countries, at the *innovation-driven* stage. The United States, Finland and Denmark are the top three countries according to the overall index values [27].

Insert Table 4 here.

When the overall mean of the countries (3.89) are compared with the overall mean of each stage, it can be seen that the overall mean of the non-competitive countries (3.40) and highly competitive countries (4.73) show significant differences from it.

The homogeneity of countries in a stage, i.e. the variation around the stage average, is calculated using the standard deviation of the overall indexes, basic requirements, efficiency enhancers and innovation and sophistication factors values of each stage (see Table 5). When the equality of stage variances is tested using the Levene homogeneity test [8], the significance values show that there is no significant difference of variance between the three stages. Therefore, the hypothesis of equal variances is rejected with a 5% confidence level.

Insert Table 5 here.

The ANOVA test results, on the other hand, show that the three stages have no common means for each of the scores. The means of the stages are not equal at 5% significance level for all variables (Table 6).

Insert Table 6 here.

In order to account for within-group variances and their corresponding stage averages simultaneously, the coefficients of variation were also calculated for each stage. The stage having the highest overall index mean (0.04) had a coefficient-of-variation value close to that of the stage with the lowest overall mean (0.08). The same situation held for both the second and third stages as well. Further the variances of the two extreme stages (1 and 3) were almost the same, as they were for the second and third stages. As a result, it can be said that, for the three stages, each have the same level of homogeneity. Although their within-group variances are the same, it is necessary to note that their respective stage averages differ from one another.

3. 2. Specification of Basic Criteria Underlying Country Stages Through ANN

In this step of the study, the basic factors underlying the reasons of a country belonging to a specific stage is analyzed using ANN. Feed-forward backpropagation algorithm is used for this purpose.

3.2.1. Artificial Neural Networks

ANN techniques have been applied to a variety of problem areas and have, in many instances, provided superior results to conventional methods [28]. The literature [3, 10, 25] suggests the potential advantages of ANN over statistical methods. The basic model of ANN techniques consists of computational units, which emulate the functions of a nucleus in a human brain. The unit receives a weighted sum of all its inputs and computes its own output value by a transformation or output function. The output value is then propagated to many other units via connections between units. The learning process of ANN can be thought of as a reward and punishment mechanism [9]. When the system reacts appropriately to an input, the related weights are strengthened. As a result, it will be possible to generate outputs, which are similar to those corresponding to the previously encountered inputs. Contrarily, when undesirable outputs are produced, the related weights are reduced. Therefore, the model will learn to give a different reaction when similar inputs occur. Thus, the system is motivated toward producing desirable results while the undesirable ones are "punished".

In multilayer networks, all the inputs are related to outputs through hidden neurons, i.e. there is no direct relation among them. As a result, in order to specify the characteristics of each input neuron and find the strength of relation between input X_i and output O_i can be found using the formula method proposed by Yoon et al. [28] and given below:

$$RS_{ji} = \frac{\sum_{k=0}^{n}(W_{ki} * U_{jk})}{\sum_{i=0}^{m}\left|\left(\sum_{k=0}^{n}(W_{ki} * U_{jk}\right)\right|}$$

In this formula, RS_{ji} shows the strength of the relation between the input I and the output j. W_{ki} is the weight between the j^{th} output U_{jk} and the k^{th} hidden neuron. Therefore, the above-given measure is the ratio of the strength of relation between i^{th} input and j^{th} output level to the sum of all the strength of relation among all the input and outputs. The absolute value in the denominator is used in order to avoid the possibility of positive relations to eliminate the impact of negative relations. Additionally, in order to increase the efficiency of the measure, the square of both the numerator and the denominator is taken as suggested by Onsel et al. [17]. The sum of the weights is set equal to 1 and in this research; the resulting modified formula is used as the basis of the analysis.

$$RS_{ji} = \frac{\left[\sum_{k=0}^{n}(W_{ki} * U_{jk})\right]^2}{\sum_{i=0}^{m}\left[\sum_{k=0}^{n}(W_{ki} * U_{jk})\right]^2}$$

3.2.2. Basic Criteria Weights

The information about the stage to which a country belongs, which was obtained as the output of the SOM in the previous stage, is used as the output of this new ANN and 178 criteria are treated as the inputs.

Ninety-three countries are used for training and 10 for testing stages. In order to obtain robust results based on different trials, for each hidden neuron number, the NN is computed 10 times and the best results obtained from each are taken. By this way, it is tried to catch different points of weight space corresponding to the network by several experiments. The smallest error ratio is obtained in a configuration with one hidden layer with 10 hidden neurons. The logistics function (logsig); is used to show the relation between input and hidden neurons, while the linear function (purelin) preferred for the relation between the hidden neurons and the output neurons. The training algorithm is gradient-descent method with momentum and adaptive learning ratio ("traingdx"). The resulting NN configuration can be seen in Figure 5.

Insert Figure 5 here.

The training is stopped, after 1000 runs where the test error began to increase (see Figure 6). At the point, the mean square error, selected as the performance measurement, is found to be 0.00021

Insert Figure 6 here.

The top ten most important inputs (criteria), playing the dominant role in the allocation of the countries to its related stage are obtained through the modified Yoon et al. [28] formula and can be seen for each stage in Table 7, 8, and 9 respectively.

Insert Table 7 here.

As can be seen in Table 7, it may be interesting to underline that the criterion playing the most important role in the construction of Stage 1, which is, in fact, composed of non-competitive countries, is military expenditure (stage average is 6.4123). This is followed by basic requirements criterion related to health, transportation etc. as well as criterion related to the bureaucracy levels.

On the other hand, due to the fact that the basic requirements concerning the health, transportation and communication structure is already reached; in the Stage 2, the criterion related to improve the quality and efficiency of the electricity, transportation, communication and fiscal infrastructure etc. are of primary importance.

Insert Table 8 here.

Finally, when the basic criteria underlying the composition of stage 3 are revealed, it can be seen that the rankings are especially related to science, research and development and technology (Table 9).

Insert Table 9 here.

3.2.3. Comparison of the Relative Importance of the Criteria in Different Country Stages

An overall evaluation can also be realized by comparing the relative importance of each criterion in the ranking of the countries belonging to different stages. For example, the "quality of education", which is one of the sub-criterion used in the GCI evaluation, has a mean equal to 2.8686 and it is the 75th most important factor in the ranking of the 1st stage (non-competitive) countries. This means that, the quality of education is not a dominant factor in the specification of the ranking of these countries. However, in the second stage (competitive countries), the same sub-criterion has a mean equal to 3.76 and is the 42nd most important criterion in the ranking while in the last stage (highly competitive countries), it is the 4th most important sub-criterion with a mean of 4.93. A similar type of analysis can be conducted for other sub-criteria.

When we analyze Table 10, 11, and 12, we can see that there are highly contrasting differences among the criteria that are of primary importance in each stage. For example for Stage 1 (non-competitive countries) *military expenditures* is the most important criterion while its relative rank is only 153 and 98 in the second and third stage respectively. Similarly *life expectancy* is the 4th important criterion in the first stage; while its rank is very low in the second and third stages of countries (148 and 149 respectively) (see Table 10).

Insert Table 10 here.

On the other hand, although *quality of electricity supply* is of primary importance for the second stage of countries, its rank is 126 and 116 for the first and third stage of countries respectively. Similar contrasting results can also be seen for *business costs of terrorism*, *railroad infrastructure development*, *postal efficiency*, and *extent and effect of taxation* (Table 11).

Insert Table 11 here.

Finally, as can be seen in Table 12, the factors that are very important for the highly competitive countries (i.e. *willingness to delegate authority*, *buyer sophistication*, *availability of scientists and engineers*, *quality of the educational system*, *cost of importing foreign equipment*) have very low ranks in the other stages.

Insert Table 12 here.

3.3. How Can Countries Switch to a Higher Stage?

In order to switch to a higher stage, a country should focus on the top five factors showing the largest difference between the average values of the higher stage and the value of the country of interest. Turkey and China are selected for illustration purposes because Turkey is our home country and has been subject to debate in its entrance process to EU. On the other hand, China which is generally referred as one of the very promising countries, contrary to the expectations, is accepted to be in the worst stage according to WEF and is only assigned to the second stage (competitive countries) in our analysis.

When we compare the largest differences in terms of the score averages of the second stage of countries with that of Turkey (1^{st} Stage, non-competitive), we can see that in order to switch to the second stage, the most important criteria that Turkey should pay special attention are summarized in Table 13.

Insert Table 13 here.

On the other hand, the basic differences of Turkey with respect to the third stage of countries (highly competitive) are summarized in Table 14.

Insert Table 14 here.

When a similar analysis is conducted to reveal the basic factors that China has to focus on in order to switch from Stage 2 (competitive countries) to Stage 3 (highly competitive countries), the largest differences are summarized in Table 15.

Insert Table 15 here.

3.4. Ranking of the Countries Based on the Proposed Weighted Criteria Index

In the third step of this research, the weights of 178 criteria for each stage that was calculated in the previous step are used to specify the ranking of the countries. For his purpose, initially, the criteria weights are normalized on stage basis and, subsequently, the score obtained by each country from each of the 178 criteria is multiplied the normalized weight of that criterion and the ranking of the 103 countries is realized according to these weighted index values.

If the ranking of the proposed model is compared with the one obtained using WEF's Global Competitiveness Index, it can be seen that, although there is an overall similarity, some important differences should also be underlined. For example, although Turkey is ranked 66th according to Global Competitive index, its rank is moved to the 53rd place according to the proposed weighted index. On the other hand, the rank of the United States is moved from the first place down to the 4th place. The countries which differ at least 10 ranks in absolute value are given in Figure 7.

Insert Figure 7 here.

In fact it is necessary to emphasize that the subjectivity of WEF clustering as well as of the weighting process sometimes result in contradictory results with respect to WEF's global competitiveness ranking index. In other words, important conflicts may occur between the stage to which a country is assigned and the rank that it gets based on Global Competitiveness Index. For example, although China is accepted to be one of the most promising countries by the authorities, WEF assigned it as Stage 1 (factor- driven economies) countries. However, it is the 31st country according to WEF's global competitiveness ranking, which shows a conflict with the previous stage assignment. Bahrain, a Stage 1 country, is ranked as the 24th country according to WEF's global competitiveness index. Similarly, Taiwan is assigned by WEF to transition stage between Stage 2 (efficiency-driven economies) and Stage 3 (innovation driven economies), while it is found to be the 10th country according to the Global Competitiveness Index. Contrarily, Spain and Italy, which are assigned as Stage 3 countries, are at the 33rd and 55th places respectively, according to global competitiveness ranking and thus they both show a lower performance than expected.

In fact, according to WEF, the countries having a GDP below a threshold level are accepted as Stage 1 countries and their key factors are assumed to be the basic requirement factors. However, this is a non-compensatory approach and there may be some countries showing very good performance in terms of basic requirements while still having a low level of GDP. Therefore, it may be unfair to assign a country to a stage based solely on its GDP level and it may be more accurate to use a compensatory approach for this purpose. On the other hand, a country may be unfairly rewarded due to its high GDP level, although it has poor performance even in terms of its basic requirement factors. For example, The United States does not score well in terms of basic requirements. However it is the world's leader in both efficiency enhancers and innovation and sophistication factors. This is mainly due to the fact that the United States is in the third stage of development (the innovation stage) and the weight of the basic requirements is relatively minor. Therefore the high values that it receives from the other two sub-indexes put this country in the leading position. Contrarily Finland leads the world in basic requirements, but it only ranks 6th in efficiency enhancers and 4th in innovation and sophistication factors.

When the same countries are analyzed using our methodology, however it can be seen that there is a complete parallelism between the stage to which a country is assigned and its place with respect to the global ranking. For example, China is assigned to Stage 2 (competitive countries, according to our terminology) and it is at the 42nd rank according to our global ranking, which shows parallelism with the previous stage assignment. Similarly, Taiwan is within the 3rd stage countries (high competitive countries according to our terminology) and it is the 16th country according to global ranking. On the other hand, Italy is assigned to Stage 2 and it is the 49th country according to global ranking, while Spain assigned to Stage 2 is the 28th country according to global ranking.

4. CONCLUSIONS

Despite the attempts to provide objectivity in the development of indicators for the analysis of the competitiveness of countries, there are obviously subjective judgments about, how data sets are aggregated and what weighting is applied. Generally, either equal weighting is applied to calculate the final index or subjective weights are specified. The same problem also occurs in the subjective assignment of countries into different stages. For example WEF assigns countries to different stages of development mainly based on their GDP level and using different subjective weights for each stage. These subjectivities may create a bias as selecting specific data seems make some countries look unrealistically good while it may underestimate the level of competitiveness of some others. This precludes intelligent use of these types of indices by executives and policy makers, which is against the very idea of publishing it.

The aim of this paper is to explore whether a methodological transparency can be an adequate solution to the above-given problems posed by the current aggregated indices. For this purpose, a methodology is proposed to objectively cluster the countries into stages as well as to reveal the weight of the criteria that play the dominant role in each stage. Subsequently, a new composite index is proposed using the calculated weights in order to avoid the pitfall of being easily dismissed by critics as just another attempt to make some countries more competitive. Developed as such the methodology is expected to provide a road map to the policy makers and executives in their way toward a more competitive country, basically focusing on the criteria necessary to move the country to a higher stage in terms of competition.

As a further suggestion, Data Envelopment Analysis can be used to benchmark the countries. Finally, Data Envelopment Analysis (DEA) can also be included in the methodology in order to provide more precise policy changes for each country under investigation [4, 5].

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FIGURES AND TABLES

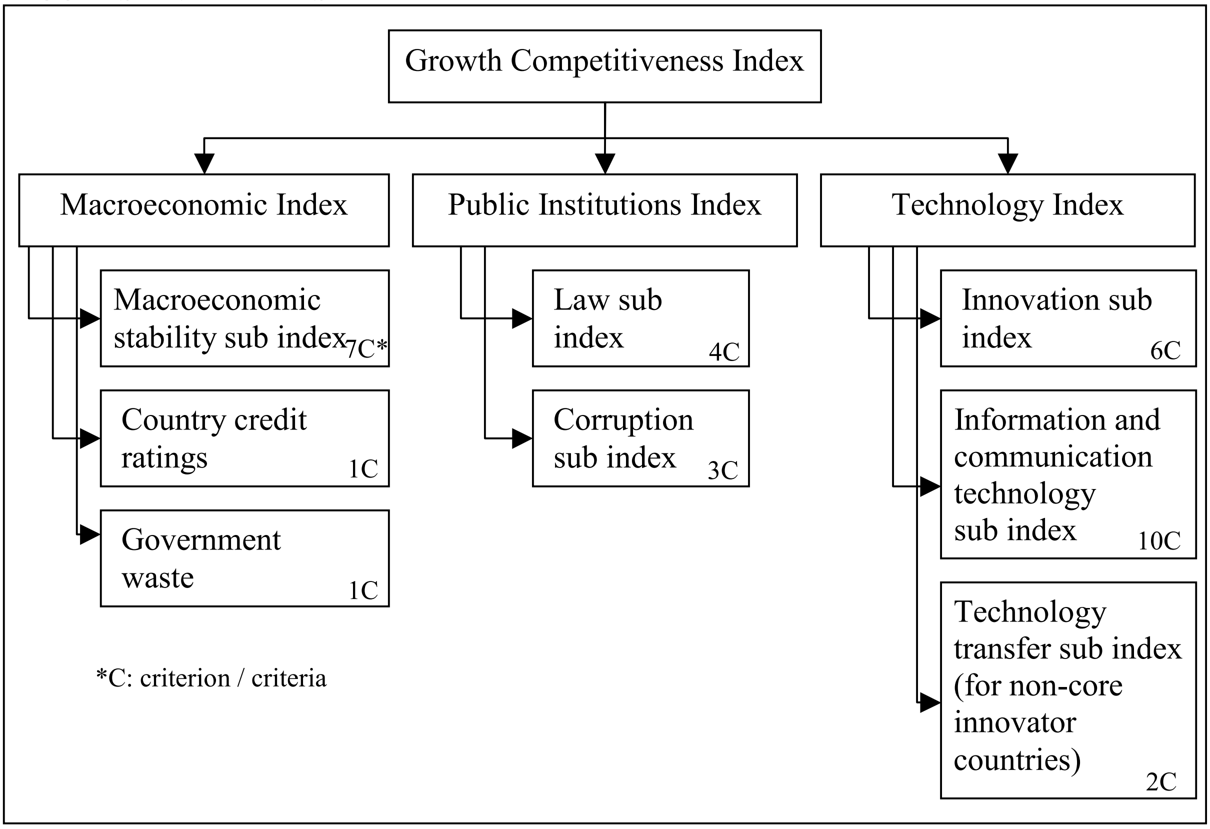

Figure 1: Growth Competitiveness Index Configuration

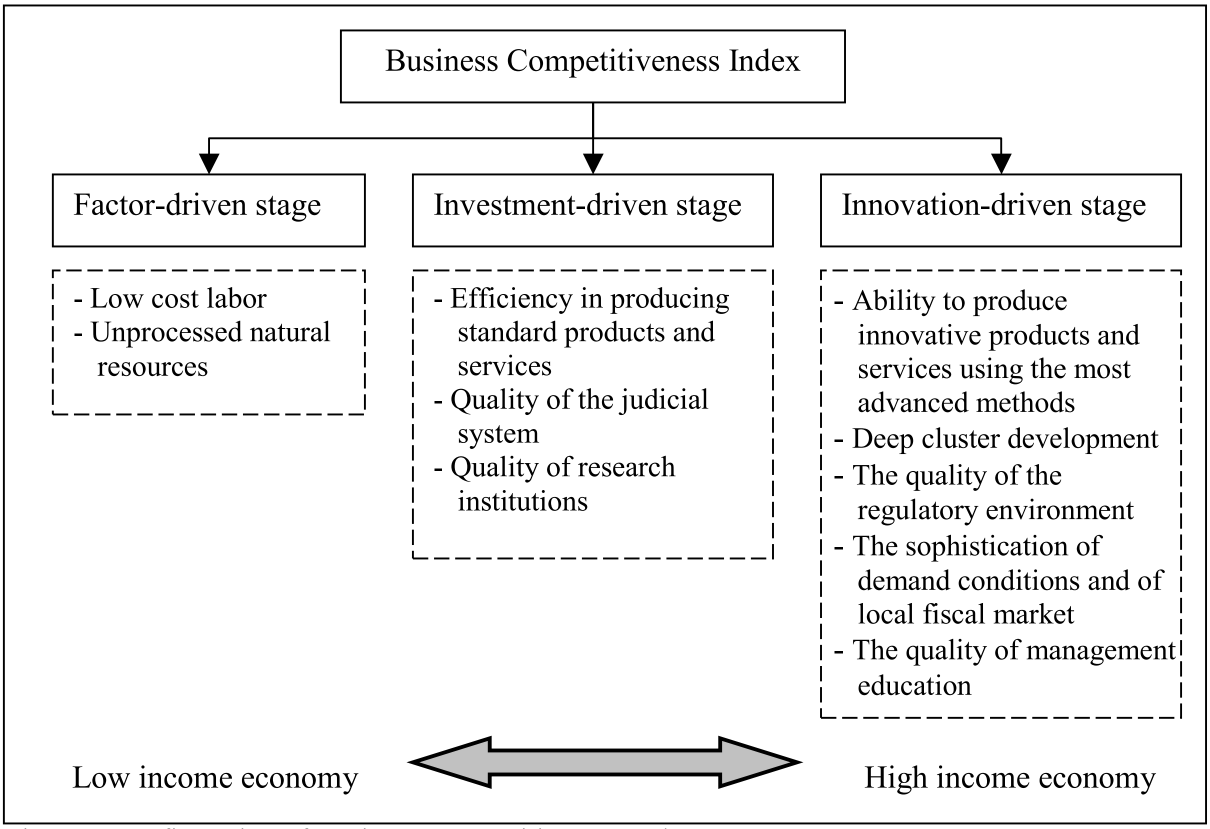

Figure 2 Configuration of Business Competitiveness Index

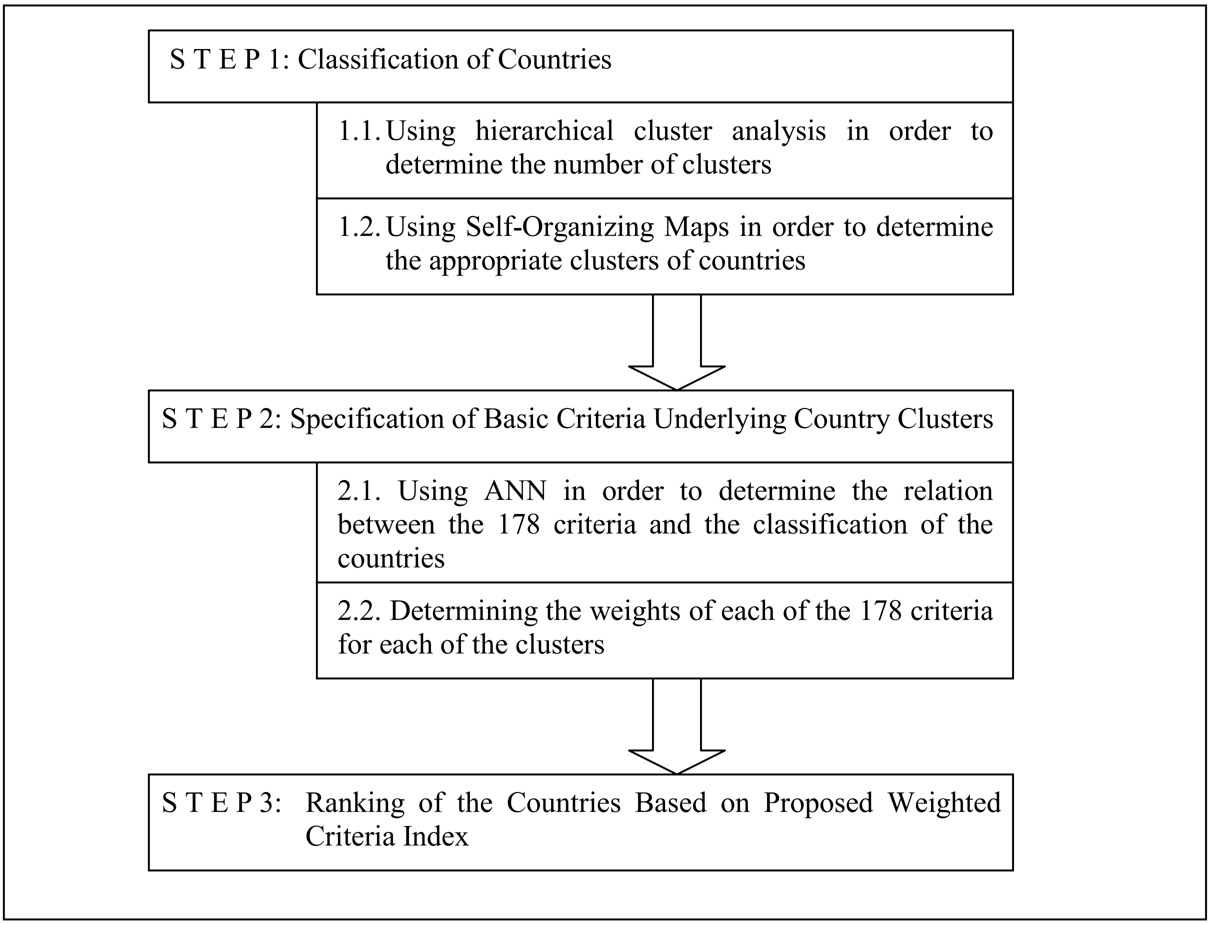

Figure 3 Flowchart of the proposed methodology

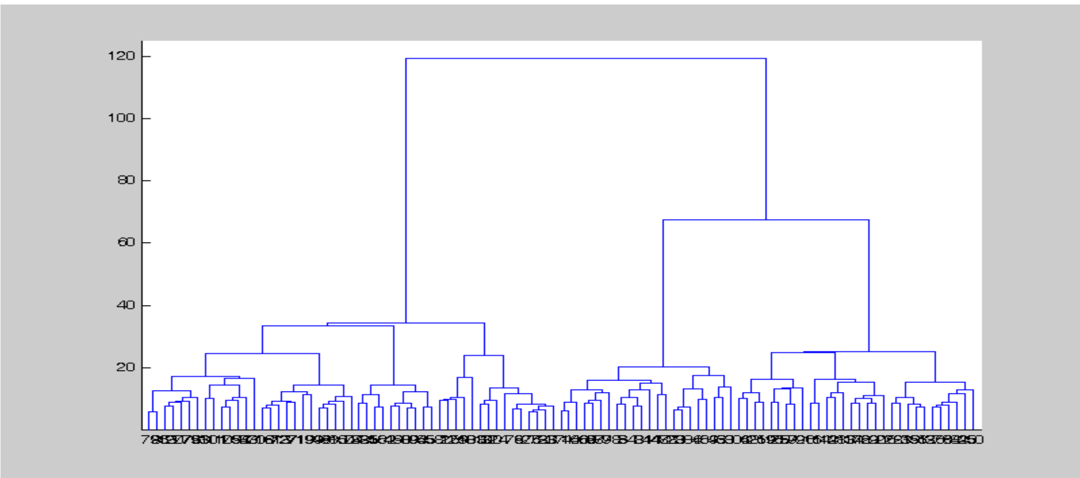

Figure 4 Dendogram of the Clusters of the countries

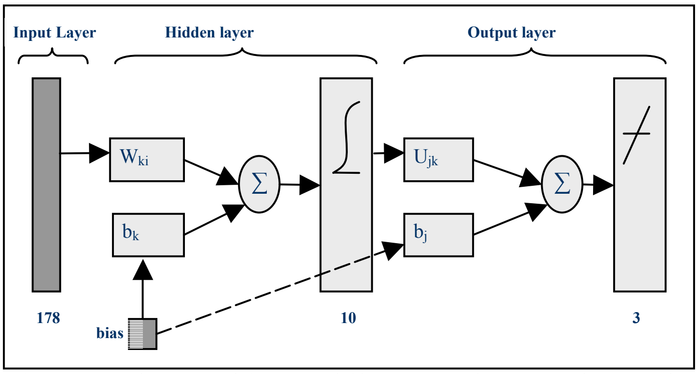

Figure 5: The Resulting Multilayer Feed Forward Neural Network Configuration

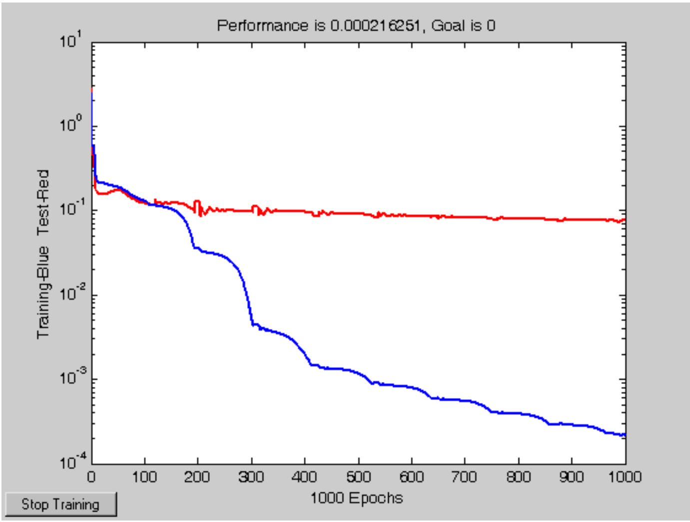

Figure 6: The learning curve of ANN

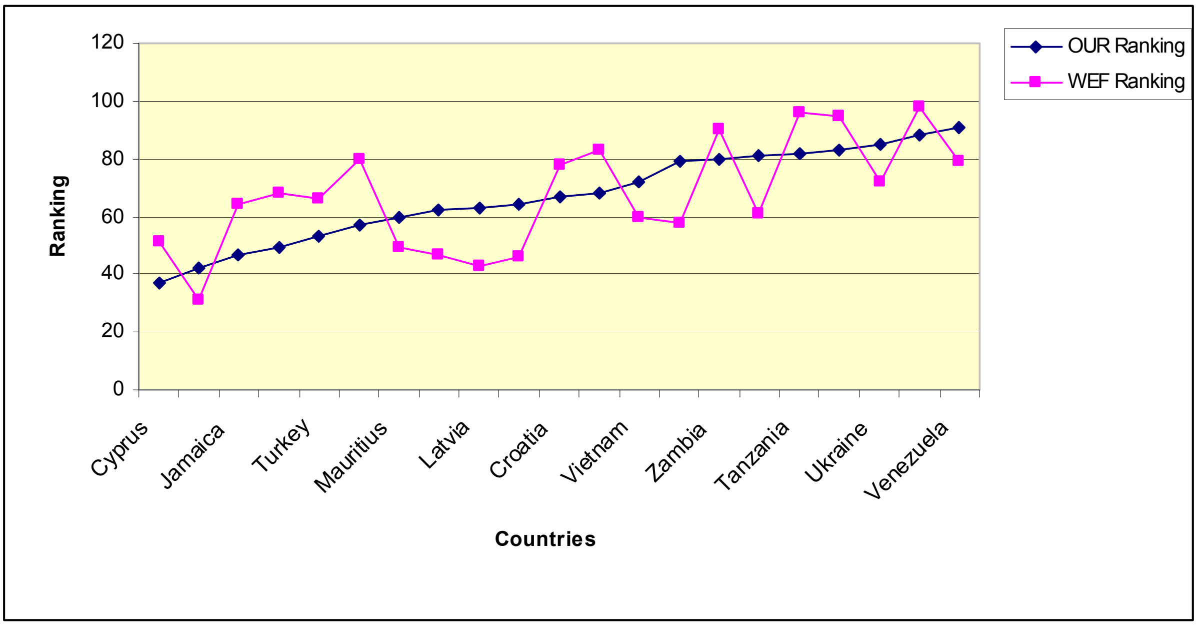

Figure 7 Significant differences between the proposed model's and WEF's rankings

Table 1 Twelve Pillars of Economic Competitiveness

#	**Pillar**
1	Institutions
2	Physical infrastructure
3	Macro-stability
4	Security
5	Human capital
6	Goods market efficiency
7	Labor market efficiency
8	Financial market efficiency
9	Technological readiness
10	Openness and market size
11	Business sophistication
12	Innovation

Table 2. Weights of the three main groups of pillars at each stage of development

Weights	Basic requirements	Efficiency enhancers	Innovation and sophistication factor
Factor-driven stage	50%	40%	10%
Efficiency-driven stage	40%	50%	10%
Innovation-driven stage	30%	40%	30%

Table 3 Non-competitive, competitive and highly competitive countries

NON-COMPETITIVE COUNTRIES		COMPETITIVE COUNTRIES		HIGHLY COMPETITIVE COUNTRIES	
Algeria	Nicaragua	Bahrain	Korea	Australia	Luxembourg
Angola	Nigeria	Botswana	Latvia	Austria	Netherlands
Argentina	Pakistan	Brazil	Lithuania	Belgium	New Zealand
Bangladesh	Panama	Chile	Malaysia	Canada	Norway
Bolivia	Paraguay	China	Malta	Denmark	Singapore
Bosnia and Herzegovina	Peru	Costa Rica	Mauritius	Finland	Sweden
Bulgaria	Philippines	Cyprus	Morocco	France	Switzerland
Chad	Poland	Czech Republic	Namibia	Germany	Taiwan
Colombia	Romania	Egypt	Portugal	Iceland	The United Kingdom
Croatia	Russian Federation	Estonia	Slovak Republic	Ireland	The United States
Dominican Republic	Serbia and Montenegro	Ghana	Slovenia	Israel	
Ecuador	Sri Lanka	Greece	South Africa	Japan	
El Salvador	Tanzania	Hungary	Spain		
Ethiopia	Trinidad and Tobago	India	Thailand		
Gambia	Turkey	Indonesia	Tunisia		
Georgia	Uganda	Italy	United Arab Emirates		
Guatemala	Ukraine	Jordan			
Honduras	Uruguay				
Jamaica	Venezuela				
Kenya	Vietnam				
Macedonia, FYR	Zambia				
Madagascar	Zimbabwe				
Malawi					
Mali					
Mexico					
Mozambique					

Table 4: The mean, standard deviation and CV

	OVERALL			BASIC REQUIREMENT			EFFICIENCY ENHANCER			INNOVATION FACTOR		
	Mean	Std Dev.	CV	Mean	Std Dev.	CV	Mean	Std Dev.	CV	Mean	Std Dev.	CV
NON-COMPETITIVE COUNTRIES	3.40	0.28	0.08	4.03	0.4	0.1	2.87	0.27	0.09	2.66	0.3	0.11
COMPETITIVE COUNTRIES	4.06	0.21	0.05	4.90	0.31	0.06	3.54	0.22	0.06	3.24	0.28	0.09
HIGHLY COMPETITIVE COUNTRIES	4.73	0.2	0.04	5.63	0.25	0.05	4.36	0.22	0.05	4.33	0.37	0.08

Table 5: Test of Homogeneity of Stage Variances

	Levene statistic	Significance
Overall	2.249	0.111
Basic	2.647	0.076
Efficient	2.166	0.120
Innovation	0.921	0.401

Table 6: Test of Equality of Stage Means

	F statistic	Significance
Overall	232.2	0.000
Basic	172.4	0.000
Efficient	290.7	0.000
Innovation	219.7	0.000

Table 7: The Ten Most Important Criteria in the Specification of Stage 1

Criteria (Input of ANN)	**Stage 1**		
	Weight Impact Score	**Stage Average**	**Impact Rank**
Military expenses	0.065034	6.4123	1
Malaria prevalence	0.04954	6.4734	2
Business impact of HIV/AIDS	0.03002	4.9109	3
Life expectancy	0.023701	4.6067	4
Real effective exchange rate, 2003	0.022362	3.2318	5
Air transport infrastructure quality	0.021878	3.6324	6
Effects of compliance on business	0.02091	4.0367	7
Extent of bureaucratic red tape	0.02075	2.8449	8
Business costs of irregular payments	0.019489	3.3206	9
Charitable causes involvement	0.018496	3.8304	10
	Mean	4.33001	
	Standard Deviation	1.2735283	
	CV	0.294116711	

Table 8. The Ten Most Important Criteria in the Specification of Stage 2

Criteria (Input of ANN)	**Stage 2**		
	Weight Impact Score	**Stage Average**	**Impact Rank**
Quality of electricity supply	0.051084	4.7392	1
Business costs of terrorism	0.037533	5.0406	2
Railroad infrastructure development	0.029629	3.186	3
Postal efficiency	0.026938	4.1733	4
Extent and effect of taxation	0.023862	3.097	5
Utility patents, 2003	0.023699	1.4498	6
Intellectual property protection	0.022795	3.7511	7
Agricultural policy costs	0.022666	3.4641	8
Cellular telephones, 2003	0.022536	3.204	9
Buyer sophistication	0.021736	4.1163	10
	Mean	3.62214	
	Standard Deviation	1.011562205	
	CV	0.279271979	

Table 9 Ten Most Important Criteria in the Specification of Stage 3

Criteria (Input of ANN)	**Stage 3**		
	Weight Impact Score	**Stage Average**	**Impact Rank**
Willingness to delegate authority	0.043035	4.4057	1
Buyer sophistication	0.040244	5.5143	2
Availability of scientists and engineers	0.038409	5.466	3
Quality of the educational system	0.031932	4.9302	4
Cost of importing foreign equipment	0.030088	4.6873	5
Company spending on research and development	0.028252	4.4758	6
Financial market sophistication	0.021718	4.9658	7
Pervasiveness of money laundering through non-bank channels	0.021196	4.6982	8
Internet access in schools	0.020998	5.4245	9
Production process sophistication	0.020188	5.0462	10
	Mean	4.9614	
	Standard Deviation	0.404417265	
	CV	0.081512731	

Table 10 Criteria of Primary Importance for Non-competitive Countries

Criteria	**Stage 1**			**Stage 2**			**Stage 3**		
	Weight Impact Score	**Stage average**	**Rank**	**Weight Impact Score**	**Stage average**	**Rank**	**Weight Impact Score**	**Stage average**	**Rank**
Military expenses	0.065	6.4123	1	0.00019	6.3467	153	0.002418	6.3642	98
Malaria prevalence	0.0495	6.4734	2	0.00335	6.6733	88	0.002141	6.9227	102
Business impact of HIV/AIDS	0.03	4.9109	3	0.00063	5.3788	137	0.006746	6.0779	51
Life expectancy	0.0237	4.6067	4	0.00032	5.2128	148	0.000269	6.0829	149
Real effective exchange rate, 2003	0.0224	3.2318	5	0.00044	3.4468	142	0.006359	3.6291	53

Table 11 Criteria of Primary Importance for Competitive Countries

Criteria	Stage 1			Stage 2			Stage 3		
	Weight Impact Score	**Stage average**	**Rank**	**Weight Impact Score**	**Stage average**	**Rank**	**Weight Impact Score**	**Stage average**	**Rank**
Quality of electricity supply	0.0006	3.7572	126	0.05108	4.7392	1	0.001428	5.9415	116
Business costs of terrorism	0.0022	4.7634	105	0.03753	5.0406	2	5.81E-05	5.2649	163
Railroad infrastructure development	0.0035	2.2988	85	0.02963	3.186	3	0.000797	4.3916	134
Postal efficiency	0.0033	3.0331	90	0.02694	4.1733	4	0.013585	5.6242	20
Extent and effect of taxation	0.0003	2.6252	141	0.02386	3.097	5	0.000262	3.5416	151

Table 12 Criteria of Primary Importance in Highly Competitive Countries

Criteria	Stage 1			Stage 2			Stage 3		
	Weight Impact Score	**Stage average**	**Rank**	**Weight Impact Score**	**Stage average**	**Rank**	**Weight Impact Score**	**Stage average**	**Rank**
Willingness to delegate authority	0.0108	2.5776	28	0.00043	3.3216	143	0.043035	4.4057	1
Buyer sophistication	0.0002	3.125	150	0.02174	4.1163	10	0.040244	5.5143	2
Availability of scientists and engineers	0.008	4.1405	42	0.00208	4.7059	104	0.038409	5.466	3
Quality of the educational system	0.0043	2.8686	75	0.00802	3.7618	42	0.031932	4.9302	4
Cost of importing foreign equipment	0.0011	2.3703	124	1.1E-05	3.3149	175	0.030088	4.6873	5

Table 13 The most important criteria that Turkey should pay attention to switch to Competitive Stage

Criteria	**Average of Stage 2**	**Turkey**
Status of banks	4.8	1.82
Government fiscal surplus/deposit as a percentage of GDP in 2003	3.15	1.37
Differences among regions in the country	3.38	1.65
Exporting companies from the country	3.48	5.16

Table 14 The most important criteria that Turkey should pay attention to switch to Highly Competitive Stage

Criteria	**Average of Stage 3**	**Turkey**
Status of banks	5.71	1.82
Intellectual property protection in the country	5.28	2.33
The share of business activity in the country that you would estimate to be unofficial or unregistered	4.04	1.15
Exporting companies from the country	3.48	5.16

Table 15 The most important criteria that China should pay attention to switch to Highly Competitive Stage

Criteria	**Average of Stage 3**	**China**
Business costs of irregular payments	5.55	1.76
National savings rate, 2003	7	3.92
Freedom of the press	5.78	2.78
Regulation of securities exchanges	5.24	2.29
Soundness of banks	5.71	2.91