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Efficiency of Socio-Economic Reforms -The assessment through Integral Index

***Samson Davoyan[1], Ashot Davoyan[2], Arpine Sargsyan[3], Davit Harutyunyan[4]**

[1]Dr. Professor; [2]PhD; [3]PhD student; [4]Master of Science of Management

ABSTRACT

For the purpose of increasing prosperity, welfare and competitiveness of the national economy, authorities of various countries carry out political, economic, social and other reforms. During this process, a number of key issues arise (i.e. how effective, interrelated and interdependent, how complex these reforms are, what comparative efficiency do they provide to other countries, etc [1]. To overcome the challenges associated with solving the above-mentioned problems, as well as to implement the multidimensional reforms within the countries, to develop and implement coherent programs of transformation, the assessment of the effectiveness of various reforms gains great importance.

With this regard, many national, international organizations develop a large number of indexes representing separate directions of transformations in different countries.

Meanwhile, the many indexes of different national and non-governmental organizations, reflect quantitative and qualitative features of some particular parts of socio-economic reforms in different countries. However, even the superficial analysis of the findings of different estimates reveals the methodological defects concerning the inclusion of the indicators included in them.

The existence of such issues and the need to find an effective solution suggests the development of a new methodology that will exclude the above-mentioned shortcomings, and will be based on a single general index, which will include as many possible indicators as possible. This new methodology and the new composite index will give a more comprehensive assessment of the different directions of socio-economic reforms.

Thus, we have developed an integral index, that quantitatively assesses the reforms implemented in more than 66 countries of the world for 2014-2018. With the help of 20 partial indexes included in the integral index we have assessed and analyzed various and multidimensional reforms in three countries of South Caucasus: Armenia, Azerbaijan and Georgia.

Index Terms : reform, comparative efficiency, index, integral index of reforms, contribution.

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Name of the Corresponding author:
Samson Davoyan*

Dr. Professor, Kazachi Post, Gyumri, Armenia

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I. INTRODUCTION

Multidimensional reforms (political, economic, social, etc) are developed and implemented by the authorities of different countries. These reforms pursue one main objective that is to respond to various internal and external challenges.

In professional researches the quantitative assessment of the above-mentioned reforms is carried out by different international and non-government organizations. Generally these assessments are made though index calculations (Global Competitiveness Index, Economic Freedom Index, Human Development Index, etc.).

Within the frameworks of our research we have developed a new integral index of various reforms that includes as many indexes as possible that partially assess different areas of reforms.

II. PROCEDURE FOR INDEX CALCULATION

The new index uses a unique methodology, which has two main parameters:

1. The change of the rank of the country by different indexes for two periods of time.
2. The change of the score of the country by different indexes for two periods of time,

After calculating ranks and scores for observed countries, we normalize the change of the score of the indexes included in the Integral Index in (0,1) interval for 2014-2018.Several steps have developed our research.

1. We have collected data and created a database of 20 partial indexes for 66 countries observed.
2. We have observed the change of country results for the observed time-period,
3. We have constructed the integral index 66 countries for 2014-2018.
4. We have extended the scope of our research by comparing the Index's results for South Caucasus - Armenia, Azerbaijan and Georgia.
5. We have applied the results achieved in the second step to conclude in which directions these countries have policies, that are more effective compared to others and in which directions they have failed.

The most outstanding advantage of our research methodology is that it is useful for evaluating social, political or economic reforms in a certain country. The results of the index can be applied to assess reforms in any other country not included in our database.

One of the most distinguishing features of this new methodology is that it allows us to add more indicators to existing ones and make the research broader - depending on the purposes and given circumstances. The integral index is designed to become a useful device for achieving high levels of efficiency in the process of reforming social, economic, political systems in any country.

III. METHODOLOGY

The research is carried out with help of the well-known method in statistics, called Principal Component Analysis (PCA). Principal Component Analysis (PCA) is a dimension-reduction tool that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set [2]. Thus, the principal component estimation enables to distinguish multiple variables from a multidimensional database, that will explain the maximum variation.

This method has several advantages, as [3];

- It is a mathematical procedure that transforms a number of (possibly) correlated variables into a smaller number of uncorrelated variables called principal components.
- The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible.
- PCA reduces attribute space from a larger number of variables to a smaller number of factors and as such is a "non-dependent" procedure (it does not assume a dependent variable is specified).
- Is a dimensionality reduction or data compression method.
- Is based on variables that have the highest correlations with the principal component.
- Etc.

The methodology is based on private analysis (eigen analysis). The first self-contained vector, which is identified with the greatest self-esteem, coincides with the direction of the first major component. The vector, which corresponds to the second largest value, determines the direction of the second major component.

The sum of the values is equal to the square matrix and the maximum number of the vectors is equal to the number of rows (columns) of that matrix.

The main idea of PCA is to reduce the number of variables of a data set, while preserving as much information as possible. This methodology seeks a linear combination of variables such that the maximum variance is extracted from the variables. It then removes this variance and seeks a second linear combination which explains the maximum proportion of the remaining variance, and so on.

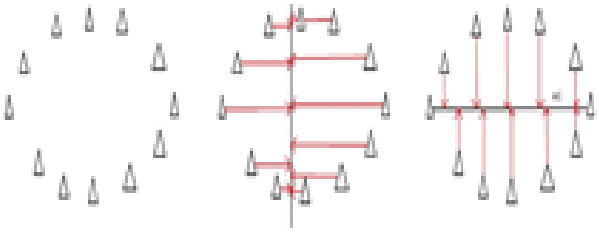
This is called the principal axis method and results in orthogonal (uncorrelated) factors. PCA analyzes total (common and unique) variance [4].

Thus, according to this methodology, the main component is the maximum variation or maximum vector of the data set.

And in this context, let's look at the simplest example to understand the essence of the main components. Consider the dataset with the scattering presented in Chart 1.

To find the direction of maximum variation it is necessary to find the straight line, along with projecting the initial data, it will include the largest dispersion.

Chart 1 **Chart 2** **Chart 3**



In the case of data projecting on the vertical line (Chart 2), the diffusion is not large, and therefore variation is small. And most likely the vertical line cannot be considered as the main component in our observation.

In the case of data projection on the horizontal line (Chart 3), the diffusion of the data is very large and the variation is maximum.

In fact, there is no straight line, along which the variance of projected values in the data set will be larger than the projection of horizontally projected values. Consequently, the horizontal line (vector) will be the main component in our example.

Mathematically, the main components are determined by their own values and their own vectors. Moreover, their values and vectors exist in pairs. Each of its vector corresponds to its own value. The vector is the direction in which the vectors in the example are in the direction of the lines (vertical, horizontal), and their own value is the number of variations in the direction of its own vector corresponding to it.

Consequently, the vector that will have the highest value will be the first major component. The number of existing values (vectors) is equal to the size of the population.

The analysis generally is conducted by several steps[1] .

Step 1: Standardization - Aims to standardize the range of initial variables so that each one of them contributes equally to the analysis. If there are large differences between the ranges of initial variables, those variables with larger ranges will dominate over those with small ranges (For example, a variable that ranges between 0 and 100 will dominate over a variable that ranges between 0 and 1), which will lead to biased results. So, transforming the data to comparable scales can prevent this problem. Once the standardization is done, all the variables will be transformed to the same scale.

Step 2: Covariance Matrix computation - Aims to understand how the variables of the input data set are varying from the mean with respect to each other, or in other words, to see if there is any relationship between them. In order to identify these correlations, we compute the covariance matrix. The covariance matrix is a p × p symmetric matrix (where p is the number of dimensions) that has as entries the covariances associated with all possible pairs of the initial variables. The sign of the covariance will show the correlation of the two variables.

Step 3: Compute the eigenvectors and eigenvalues of the covariance matrix to identify the principal components. Eigenvectors and eigenvalues are the linear algebra concepts that we need to compute from the covariance matrix in order to determine the *principal components* of the data. Principal components are new variables that are constructed as linear combinations or mixtures of the initial variables. The principal components are less interpretable and don't have any real meaning since they are constructed as linear combinations of the initial variables. Geometrically speaking, principal components represent the directions of the data that explain a **maximal amount of variance**, that is to say, the lines that capture most information of the data. As there are as many principal components as there are variables in the data, principal components are constructed in such a manner that the first principal component accounts for the **largest possible variance** in the data set. The second principal component is calculated in the same way, with the condition that it is uncorrelated with (i.e., perpendicular to) the first principal component and that it accounts for the next highest variance [5]. This continues until a total of p principal components have been calculated, equal to the original number of variables. Thus, eigenvectors of the Covariance matrix are actually *the directions of the axes where there is the most variance* (Principal Components). And eigenvalues are simply the coefficients attached to eigenvectors, which give the *amount of variance carried in each Principal Component*.

By ranking eigenvectors in order of their eigenvalues, highest to lowest, we get the principal components in order of significance.

Step 4: Feature vector - In this step, we choose whether to keep all these components or discard those of lesser significance (of low eigenvalues), and form with the remaining ones a matrix of vectors that we call Feature vector. The feature vector is a matrix that has as columns the eigenvectors of the components that we decide to keep.

Step 5: Recast the data along the principal components axes - In the last step, we use the feature vector formed (based on the eigenvectors of the covariance matrix), to reorient the data from the original axes to the ones represented by the principal components. This can be done by multiplying the transpose of the original data set by the transpose of the feature vector.

$$FinalDataSet = FeatureVector^{T} * StandardizedOriginalDataSet^{T}$$

IV. DATA COVERAGE

The integral index is based on 20 partial indexes, includes estimates for 66 countries for the period 2012-2018. It should be noted that the partial indexes included in the composite / integral index have been harmonized in accordance with the direction of change and adjusted so that they fluctuate in the 0 (min) -10 (maximum) range.

Table 1: The partial indexes used for analysis

1	Travel and Tourism Competitiveness Index TTCI	The index assesses the extent to which nations and regions are putting in place the factors and policies to make it attractive to develop the travel and tourism sector. The Index scores range from 1 to 6. The TTCI is based on three main sub-indexes (regulatory framework; business environment and infrastructure; human, cultural and natural resources).
2	Environmental Performance Index EPI	The index measures the observed countries' performance efficiency on high-priority environmental issues in two brad policy areas: protection of human health from environmental harm and protection of ecosystems.
3	Global Gender Gap Index GGGI	The Index benchmarks national gender gaps of evaluated countries on economic, political, education- and health-based criteria.
4	Corruption Perception Index CPI	The Index measures the perceived levels of public-sector corruption based on different assessments and business opinion surveys.
5	Index of Economic Freedom EF	The index assesses the economic freedom of countries through 12 pillars. All pillars of the Index are scaled equally. The scores of individual pillars range from 0 to 100; countries that get 100 are the freest economies of the world.
6	Democracy Index DI	The Index includes 60 indicators grouped in five pillars: electoral process and pluralism, civil liberties, functioning of government, political participation, and political culture.
7	Doing Business Index DB	The index assesses business activity in different countries on the basis of 11 areas of regulation (starting a business, dealing with construction permits, getting credits, paying taxes, etc.). The Doing Business index is calculated by the World Bank and International Financial Corporation.
8	Global Peace Index GPI	The index measures the relative position of nations' and regions' peacefulness. It includes 23 indicators that measure the existence of absence violence or fear of violence.
9	Global Competitiveness Index GCI	The index contains 3 sub-indexes, which, in turn, are based on 12 pillars (infrastructure, institutions, market size, health and primary education, higher education and training, etc.). The spectrum of the GCI includes 119 indicators.
10	Anti money Laundering and Terrorist Financing Index /Basel AML	The Basel AML (anti-money laundering and counter terrorist financing) Index measures the risk of money laundering and terrorist financing of countries based on publicly available sources.
11	Legatum Prosperity Index LP	Legatum Prosperity Index is an annual ranking based on a variety of factors including wealth, economic growth, education, health, personal well-being, and quality of life. The index is based on 8 sub-indexes and 89 different indicators.
12	Social Progress Index SPI	The SPI measures the level of social development and wellbeing, it is based on 12 pillars (that include 52 indicators), grouped in 4 sub-indexes.
13	Human Development Index HDI	The Index measures a standard of living, the literacy rate, the life expectancy in order to compare and assess the human potential of different countries.
14	Global Innovation Index GII	The index assesses innovation capabilities and results in evaluated economies. The GII consists of two sub-indexes: the Innovation Input Sub-Index and the Innovation Output Sub-Index, each built around pillars.
15	Human Capital Index HCI	The Index ranks 130 countries on how well they are developing their human capital. The Index's score is calculated on a scale from 0 (worst) to 100 (best).
16	Bertelsmann Transformation Index BTI	The BTI analyzes and evaluates the quality of democracy, market economy and political management in number of developing and transition countries. It measures successes and setbacks on the path toward a democracy based on the rule of law and a socially responsible market economy.
17	Logistics Performance Index LPI	The LPI uses six key dimensions to benchmark countries' performance. The index's scorecards demonstrate comparative performance – the dimensions show on a scale (lowest score to highest score) from 1 to 5 relevant to the possible comparison groups – of all countries, region and income groups.
18	Fragile States Index FSI	The index is a critical tool in highlighting not only the normal pressures that all states experience, but also in identifying when those pressures are pushing a state towards the brink of failure.
19	Global Talent Competitiveness Index GTCI	The GTCI is an annual benchmarking report that measures the ability of countries to compete for talent. It aims to advance the current debate around entrepreneurial talent, providing practical tools and approaches to leverage the full potential of individuals and teams as an engine and a basis for innovation, growth, and ultimately competitiveness. The report covers 125 economies and 114 cities.
20	Freedom of Press Index FOTP	Assesses the degree of freedom available to journalists in 180 countries. and is determined by pooling the responses of experts to a questionnaire devised by RSF. The criteria evaluated in the questionnaire are pluralism, media independence, media environment and self-censorship, legislative framework, transparency, and the quality of the infrastructure that supports the production of news and information.

Construction of a general assembly

Thus, after the data processing, the main components have been estimated based on the above described method. The Integral index was calculated as the weighted average of the main components through the formula below.

$$GI_t = \sum_{t=1}^{p} w_i F_{it}$$

Where,

- GI_t - the Integral index;
- F_{it} - the principal component,
- w_i - the weight corresponding to each of the principal components.

For the analysis of principal components, it is important to determine the number of major components (F_t) that is based on the analysis of the analysis of root matrix.

Detailed information about all principal components and their values are presented below in the Table 2. The root matrix of the used indexes (20 columns) has its own root values greater than or equal to 0.4. Using their estimated roots, it is possible to calculate the proportion of each principal component of variation in the general variation of the used indexes. As our study incorporates 20 variables, the variations of the standardized variables are equal to 1, so the total variation will be equal to 20. The variation of the first principal component is equal to the largest root of the correlation matrix, i.e. 13.7, so the share (weight) of the first component will be 68.5% (13.7 / 20 * 100) in the variation of the index, the proportion of the second component variation will be relatively small calculated by analogy and so on. The third column of the table shows the share of cumulative variation of principal components in the general variation of the used indexes.

Table 2: The principal Components and their weights in the Integral Index:

	estimated roots	The % share (weight) in the total variation of the index	The % share of cumulative variation
PC1	13.7	68.5%	68.5%
PC2	1.2	6.1%	74.6%
PC3	0.97	4.8%	79.4%
PC4	0.82	4.1%	83.5%
PC5	**0.59**	**3.0%**	**86.4%**
PC6	0.49	2.5%	88.9%
PC7	0.44	2.2%	91.1%

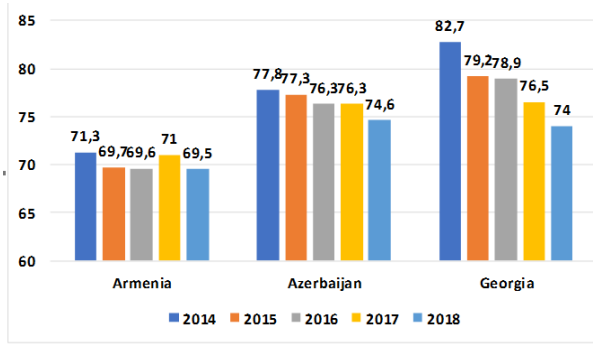
The construction of the platform is carried out in accordance with Resolution 1, where we used the first five components assessed by the method of the principal components. The weight of each principal component has been used as the weight of the five major variations of variants.

To check the accuracy of the used indicators for the factor analysis we have applied the Kaiser-Meyer-Olkin (KMO) test, which, indicates a high degree of compliance with the indicators used in the factor analysis. Specifically, the result of the KMO test, from the range 0-1, was quite high for our analysis, 0.94.

V. RESULTS FOR SOUTH CAUCASUS

As the interpretation of the Index we have made Let's sum up the dynamics of the ratings of the three South Caucasian countries, Armenia, Georgia and Azerbaijan, estimated on basis of the 20 partial indexes for the period of 2014-2018.

Figure 1. The results of the Integral Index of Reforms, Armenia, Georgia, and Azerbaijan in



According to the data indicated in the figure 1, Georgia is the leader among the three South Caucasus countries in terms of World Peace, Human Development, Tourism and Tourism Competitiveness, Social Progress, Global Innovation, Democracy, Transformation, Press Freedom, Corruption Perception, Doing Business and Prosperity Indexes.

Azerbaijan is the leader according to the environmental efficiency, competitiveness of talents, Global Competitiveness, Money Laundering and Terrorist Financing Indexes. Azerbaijan has negative shifts according to the indexes of Tourism and Tourism Competitiveness, Freedom of the Press and Democracy.

According to the figure data, for the observed period, the change in the overall rating, Armenia has positive indicators according to Environmental Performance, Doing Business, Money Laundering and Terrorism Financing Indexes, and the greatest negative impact have indexes of Human Capital, Travel and Tourism Competitiveness and Logistics Efficiency.

VI. CONCLUSIONS

To sum up, based on the scientific and empiric results of our research, we can make the following conclusions:

- ✓ The Integral Index of Reforms is a unique and comprehensive methodology, that can become a guidance for many authorities to reveal which directions of reforms were implemented more effectively and also the areas of reforms with less efficiency for to strengten all advantages and eliminate disadvantages.
- ✓ The indicators included in the research are useful for thorough analysis in any area concerning particular country's political, economic, social development.

- ✓ The results of our research on the Integral Index and the assessment of comparative analysis give an opportunity to conclude that this index can be very useful in analysis in different fields.
- ✓ The methodology gives the opportunity to include more indexes and indicators that partially reveal quantitative assessment of the reforms and their implementation in some areas. Thus the synergy effect of those indicators will help to reveal the efficiency of reforms more integrity.
- ✓ Furthermore, the methodology can be applied in both economics and other social sciences (sociology, statistics, etc.).

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