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EFFICIENCY RANKING OF PROVINCES IN TURKEY USING NUTS-3

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Abstract

The study measures the regional efficiencies of provinces in Turkey using NUTS (Nomenclature of Territorial Units for Statistics) Level 3 data. Principal component analysis (PCA) and data envelopment analysis (DEA) are used. The principal component analysis was used for the data preparation phase, resulting in the data being expressed in 12 components. Additionally, the result from the principal component analysis was interpreted on its own on a per-province basis. The output-oriented CCR and BCC models of data envelopment analysis were employed and the results were ranked using super efficiency. The efficiency scores of the provinces were determined and interpreted within that framework. The results from PCA and DEA activities were compared and the relationships between the two result sets were tested using Spearman Rank Correlation. The SPSS statistics software was used for principal component analysis, and the EMS (Efficiency Measurement System) software was used for data envelopment analysis.'

Keywords:Data envelopment analysis (DEA);Efficiency and productivity;Principal component anaysis (PCA);

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1. Introduction

Principal Component Analysis (PCA) can be used to convert a series of related p variables into uncorrelated hypothetical entities called principal components; this is performed to stabilize predictions, to evaluate multivariate normality and to determine variances [1]. Data Envelopment Analysis (DEA) is preferred by researchers because of its ability to handle multiple inputs and multiple outputs, to eschew the need to associate inputs and outputs, and to compare the efficiency of decision making units (DMU) with a reference group or groups [2].

The data used in the analyses was obtained from the Turkish Statistical Institute and from The Bank Association of Turkey. The analyses were based on NUTS (Nomenclature of Territorial Units for Statistics) Level 3 data and conducted for all 81 provinces in Turkey. With a goal towards devising complete data sets, those indicators which did not include data points for all provinces were left out of the analyses.

Following the factorization performed using PCA, 12 principal components were obtained and a score-based ranking of the provinces was generated. Output-oriented BCC (Banker-Chames-Cooper) and CCR (Charnes- Cooper-Rhodes) models for data envelopment analysis were employed to determine the efficiency for the provinces, which were then ranked using a super-efficiency model. Reference provinces were provided for non-efficient provinces and steps required to achieve efficiency are described. Results obtained from PCA and DEA were compared and any relationships were explored using Spearman Rank Correlation. Statistically significant relationships were discovered among the ranking for seven dimensions (Labor Force, Energy and Justice, Transportation, Environment, Agriculture, Housing, and Banking). During the implementation of the study, the SPSS statistics software was used for principle component analysis, and the EMS (Efficiency Measurement System) software was used for data envelopment analysis.

LiteratureReview

[3] "Efficiency Evaluation of Provinces in the Black Sea Region of Turkey Using Data Envelopment Analysis": By examining the socio-economic makeup of the 18 provinces located in the Black Sea region of Turkey, the study attempts to evaluate the performances of the

provinces by employing the CCR approach for data envelopment analysis, a method used for measuring the efficiency of decision making units having multiple inputs and multiple outputs. As a results of the analyses, the efficiency levels of the provinces were determined and recommendations were developed to increase their levels of relative efficiency. Additionally, strengths and weaknesses of the provinces were determined and attempts were made to identify, accordingly, the types of social and economic transformations required.

[4]"Relative Efficiencies of Provinces in Resource Usage within the Context of Regional Competitiveness: An Application of Data Envelopment Analysis": This proficiency thesis submitted to the State Planning Organization of Turkey examines, using data envelopment analysis, the resource usage efficiencies of provinces in Turkey in their production processes related to added value. In determining the inputs and outputs for the process, principal components contributing to regional competitiveness were utilized, in addition to public resources. As well as identifying relative technical efficiencies and scale efficiencies for the provinces, the results of the study also provide information, on a province basis and for Turkey as a whole, for underutilized resources and the degrees of inefficiency with which such resources are inefficiently utilized.

[5] "A Comparison of Province Development Levels Using Statistical Analyses and DEA": Using economic, social and socio-demographic variables, the goal of the study is to rank provinces per their level of development with the help of multivariate statistical analysis methods and nonparametric efficiency analyses, and to determine those provinces within the resulting ranking that efficiently utilize their resources. Efficient provinces, to serve as references for other provinces in Turkey, were determined in line with the objective of the study. A fundamental goal of the study is to compare the success rates of the multivariate analysis and data envelopment analysis methods in determining the development levels of provinces, and to discuss which methodology is more effective for advanced ranking. The results indicate that the effectiveness of the DEA method decreased compared to that of the multivariate statistical analysis method, as the number of variables increased.

[1] “Evaluation of the Economic Efficiencies of Priority Provinces for Development Using Data Envelopment Analysis”: The dissertation thesis examines whether or not the economies of the provinces in Turkey, designated as priority provinces for development during the period from 1995 to 2000, have been efficient. In the study, realized public investments, incentivized investments, and total issued bank credits were specified as inputs, and GDP, number of new businesses, and foreign trade balance were specified as outputs, at a per province basis. The Super Slack Based Model (SupSBM), deemed most suitable for the study among DEA models, was utilized, and DEA Solver Pro 4.1 software was used for conducting the analysis. It was determined that between the years 1995 and 2000, on an annual basis, the total number of relatively efficient provinces were less than the total number of inefficient provinces, and that the most number of efficient provinces was created in 1996, which also was the peak year for the curve representing average annual efficiency values. It was deduced that the policy of designating priority provinces for development, implemented by political administrations, shall be continued as a policy that provides support to economies of provinces and their competitiveness.

[6] “An Analysis of the Implementation of Policies Towards Eliminating Differences in Interregional Development and Efficient Usage of Resources in Turkey”: The paper, a Ph.D. dissertation, has two interrelated and fundamental goals. The first is to place within a framework the policies in Turkey towards eliminating differences in interregional development; the second goal is to determine whether regional resources have been used efficiently and to propose alternative policies for more efficient use of the aforementioned resources. In light of these goals, 26 subregions in Turkey, identified per NUTS Level 2, have been analyzed using data envelopment analysis, a model that helps in measuring the relative efficiencies among decision making units. As a result of the analysis, an attempt is made to evaluate the economicstatus of those subregions that were determined, based on their placement in socio-economic development ranking, not to efficiently use resources. Analysis findings were insufficient to conclude that the subregions placing lower in the socio-economic ranking inefficiently used resources.

[7] “The Use of DEA to Determine Economic Efficiencies of NUTS Level 2 Regions in Turkey and an Application of the Tobit Model”: The paper examines the economic efficiencies of NUTS

Level 2 regions in Turkey for the years 2007 and 2008. DEA, a non-parametric measurement methodology, is used to determine the economic efficiencies of regions. For the analysis, realized public investments per capita, incentivized investments, and total issued bank credits were specified as inputs, and gross value added, number of new jobs created using incentives, number of new businesses, and foreign trade balance were specified as outputs, per each region. In successive stages of the study, the Tobit model was utilized to examine the effects of the "input and output variables" on economic efficiencies.

[8] "Study of Regional Eco-Efficiencies in Turkey Using Data Envelopment Analysis": The conference paper defines "eco-efficiency" as a metric used in sustainability analyses that provides an indication of the efficiencies of economic activities with respect to their effects on the environment. The study examines the eco-efficiencies of 26 regions in Turkey, identified per NUTS Level 2, with the help of a model developed using data envelopment analysis. In the analysis, the gross value added (GVA) measure was chosen to represent economic activity. Environmental duress was taken into consideration through released gases causing acid rain, global warming, tropospheric ozone and particulate matter, as well as waste water and solid waste. The findings indicate that regions with higher GVA have a higher eco-efficiency compared to regions with lower GVA.

[9] "Socio-Economic Development of Districts in Turkey": The paper is a cornerstone study revealing development disparities among regions and providing a related ranking. Principal component analysis has been used as the analysis method in the study. The study addresses the administrative makeup of Turkey in effect in December 1993 and thus involves 858 provinces. 32 variables, assumed to exhibit the socio-economic structure of districts, have been reduced, through principal component analysis, to 6 principal components. The resulting ranking reveals that the most developed districts are located in the Marmara region, followed in order by the Aegean, the Mediterranean, Central Anatolia, Southeast Anatolia, and East Anatolia regions. Additionally, the study finds that the central districts placing near the top of the rankings are followed by districts with high incomes generated through tourism activity. Finally, various information is provided pertaining to the developed districts.

[10] “Long-Run Growth Trends and Convergence Across Indian States”: The OECD working paper examines the growth performance of Indian States during 1970-1994, using a combination of principal component analysis and panel data estimation techniques. The study finds that economic policy measures aimed at improving the availability of physical, economic, and social infrastructure can have a significant impact in promoting long-run growth.

[11] “Socio-Economic Development in India: A Regional Analysis”: The study examines the existing disparity in development levels of Indian states and attempts to identify causes. In lieu of studying the deviations of a particular variable across states, a composite index based on several indicators was developed using principal component analysis and the states were categorized based on indices derived using four broadly accepted components. The findings of the analysis support the general perception about the states.

[12] “Using Principal Components to Produce an Economic and Social Development Index: An Application to Latin America and the U.S.”: The paper presents a principal components methodology for determining the weights for a set of indicators in a composite index of development. The procedure was applied to a 36-variable data set consisting of 1990 data for 19 Latin American countries and the corresponding 1960 and 1990 data for the individual U.S. states. The overall finding is that the level of development of Latin American countries in 1990 is roughly distributed over the U.S. states of 1960.

[13] “A Multivariate Methodology to Uncover Regional Disparities: The Socio-Economic Development Index of Provinces in Turkey”: Using a comparative approach, the study conducts analyses over two points in time. 48 variables for the first time point, and 47 variables for the second time point, are used. A ranking of the provinces in Turkey and variances in their socio-economic development indices are provided for two time periods. Disparities among provinces per their socio-economic development indices were observed to grow over the two time periods. Economic status of the provinces for the two time periods were examined, and it was observed that socio-economic development indices improved in a direction moving from the eastern to the western regions of Turkey.

[14] "Research on the Socio-Economic Development Ranking of Provinces and Regions in Turkey": The study is qualified as the most complete resource uncovering the socio-economic disparities among provinces and regions of Turkey and provides a ranking for the same. The study covers all 7 geographical regions and all 81 provinces, using 58 variables selected from economic and social domains. Principal component analysis is the analysis technique used. The study discusses the concepts of development, growth, progress and sustainable development, and covers the phenomenon of socio-economic disparity and its associated issues, in Turkey as well as in the world at large.

[15] "Research on the Socio-Economic Development Ranking of Districts in Turkey": The study aims to determine the socio-economic development levels of districts in Turkey and to provide a development-based ranking of the districts based on the research. Additionally, the same data set was used to partition into 6 groups those districts having similar attributes, and the economic status of the districts based on the grouping have been provided. Districts from Ankara, İzmir and İstanbul provinces were deemed to be developed and were thus excluded from the study. 32 variables collected from a total of 872 districts were subjected to principal component analysis and 7 principal components were then obtained. Of the 25 districts placing at the top of the ranking, 12 were revealed to be central districts while the rest were districts with growing industrial and tourism sectors.

[16] "Examining with Principal Components Analysis the Socioeconomic Development Levels of Provinces in Turkey According to Geographical Regions": The study was implemented over two separate periods (1990-1994 and 1995-2002) using indicators that were chosen from several distinct domains, including education and culture, healthcare, employment, social security, finance, manufacturing industry, agriculture, foreign trade, energy, housing and infrastructure sectors, as well as sectors based on geography and demographics.

[17] "New Approaches to Grouping Provinces in Turkey Based on Socio-Economic Development Levels": In the study, 81 provinces in Turkey have been classified using 16 socio-economic variables and multivariate statistical analysis methods, including clustering,

discriminant analysis, principal component analysis and multidimensional scaling analysis. For every analysis type, each province was categorized separately.

[18] "A Study on the Comparison of Data Envelopment Analysis and Multivariate Statistical Methods for Ranking and Classification of the Development Levels of Provinces in Turkey": The study comparatively examines application of DEA and multivariate statistical analysis methods in the ranking and classification of the development levels of provinces in Turkey represented by 14 socio-economic and demographic variables. According to the study, a high degree of correspondence was found to exist between the results from the analysis methods (split analysis and clustering) used for categorization, and the results from the analysis methods (principal component analysis and DEA) used for ranking.

[19] "Determining the Socio-Economic Development Levels of Provinces in Turkey": The study attempts to determine the development levels of 81 provinces in Turkey based on 28 socio-economic variables examined, using principal component analysis and factor analysis. A set of 4 principal components are obtained as a result of principal component analysis and based on the mentioned components, development scores for each province are generated.

[20] "A Ranking of European Union Countries Using Data Envelopment Analysis and Principal Component Analysis": The Ph.D. dissertation processed the socio-economic data for 28 countries for the period from 1998 to 2003 to calculate their total factor efficiencies using the Malmquist index, and identified the relative efficiencies for the year 2003 based on the DEA models CCR and BCC; finally, the reference countries were used to interpret the economic status of the remaining countries. A strong and proportional relationship between the DEA and PCA score numbers was observed.

[21]"Socio-Economic Development Ranking of Regions in Turkey: A Principle Component Analysis": The study presents the socio-economic development levels of, and disparities among, the statistical territorial units in Turkey using NUTS Level 1 data. The principal component analysis method is used in the study, due to the ability of this method to eliminate dependencies

among variables and allow reduced-dimension representations. The initial 10 variables were reduced to 2 principal components.

[22] “Who’s in First? A Regional Development Index for the People’s Republic of China’s Provinces”: The study puts together a regional development index for China in order to measure regional development across regions using 10 field indices and one reference index. The reference field index represents the natural endowments of a province. A total of 70 basic indicators for 31 provinces were used and the principal component analysis method was employed.

[23]“Socio-Economic Development Ranking of Provinces in Turkey”: The goal of the paper is to provide an update, using currently availableup-to-date data and covering provinces only, for the study on the development ranking of regions and provinces conducted by the State Planning Organization of Turkey (DPT) in 2003 and for which a report was issued (“DPT-2003”). The data contained in the DPT-2003 report is included in the study; principal component analysis method was used. As a result of the analysis, 41 social and economic variables were reduced to 8 principal components. Of these 8 components, the most descriptive component was termed the “development causative factor”.

[24] “Socio-Economic Development Index for the TR-52 Region Districts in Turkey”: Using 32 variables, the study puts together a socio-economic development index for the TR-52 region in Turkey, a NUTS Level 2 region comprised of the provinces of Konya and Karaman. A ranking of the districts is provided per the aforementioned index. Proposals are presented to improve on the development disparities among the districts included in the study.

[25] “Study on Development Levels of Provinces in Turkey”: The study attempts to measure the existing and potential development level rankings of provinces. At the outset of the study, the development indices for the provinces, comprised of 44 variables [economic indicators (27 variables), social indicators (10 variables) and labor force indicators (7 variables)], were reduced to 10 principal components; the most descriptive of these was termed the general causative factor. Then, a ranking for development index for provinces was calculated and the provinces

were divided into 5 groups based on their indices in the said ranking. This provided the opportunity to perform detailed explorations for the provinces contained in identical groups.

[26] “Evaluation of the Economic Performances of Provinces in Turkey Using Data Envelopment Analysis and Principal Component Analysis”: The Ph.D. dissertation study determined the efficiencies of all 81 provinces in Turkey using the output-oriented BCC model of the DEA models available; then, principal component analysis was applied to the same data set, obtaining scores for the principal components. A ranking of the provinces was generated based on the findings.

[27] “Comparative Analysis of the Socio-Economic Development Levels of Turkey and European Union Member States”: The study applied principal component analysis to the 28 member states of the EU as well as to 19 indicators for Turkey, arriving at a ranking for Turkey among EU nations, based on the results of the generated index.

The “SEGE-2011” (“Socio-Economic Development Ranking”) [28] report issued by the Turkish Republic Ministry of Development in 2013 has served as the foundation for the spatial dimension of the new system of government incentives put in place in 2012. The province development levels were measured using variables from various fields and a ranking of the provinces was generated using the measurements and accompanied analyses; groups of provinces having similar attributes were identified. The study was prepared using 61 variables in 8 categories (demographics, education, healthcare, employment, competitive and innovative capacity, financial capacity, accessibility, and quality of living); most of the variables pertain to years 2009 and 2010.

2. Research Method (10pt)

2.1.Data Envelopment Analysis (DEA)

DEA, conceived by Charnes, Cooper and Rhodes (1978), is a nonparametric, linear programming-based technique that measures the relative efficiencies of similar decision making units. Relative efficiency, at the core of the data envelopment analysis method, is the corresponding efficiencies of units within a database that are the subjects of the analysis at hand [5].

2.1.1Charnes-Cooper-Rhodes (CCR) Model

This is the first and fundamental DEA model conceived by Charnes, Cooper and Rhodes (1978) [29]. The model assumes constant returns to scale and calculates the total efficiency scores of decision making units. Total efficiency score is the multiplication of the technical efficiency value by the scale efficiency value; following determination of resources, it produces an estimate for the inefficienct units [30], [31].

The CCR method is based on the assumption of constant returns to scale. If the efficiency of the j^th decision making unit is h_j, the goal should be the maximization of this efficiency value. In this case, the objective function may be represented as in (1) under the input orientation assumption [31].

$$Enbh_j = \frac{\sum_{r=1}^{n} u_r y_r}{\sum_{i=1}^{m} v_i x_i} \quad (1)$$

Constraints may then be expressed as shown in (2):

$$\begin{aligned} &\frac{\sum_{r=1}^{n} u_r y_r}{\sum_{i=1}^{m} v_i x_i} \le 1 \\ &u_r \ge 0 \\ &v_i \ge 0 \end{aligned} \quad (2)$$

2.1.1.1. Input-Oriented CCR Model

This model strives to find the level of minimization necessary on the combination of inputs, so as to obtain the most efficient outcome for the current level of outputs without changing them [32]. The CCR model forms the foundation for data envelopment analysis. The dual and primal models, based on the CCR model itself, have been developed to compensate for the shortcomings of the CCR model.

The model is defined as shown in (3) and (4):

$$Enbh_j = \sum_{r=1}^{n} u_r y_r \qquad (3)$$

$$\sum_{i=1}^{m} v_i x_i = 1$$

$$\sum_{r=1}^{n} u_r y_r - \sum_{i=1}^{m} v_i x_i \geq 0 \qquad (4)$$

$$u_r, v_i \geq 0$$

Equations (3) ve (4) have been devised for input orientation.

2.1.1.2. Output-Oriented CCR Model

This model strives to find the level of maximization necessary on the combination of outputs, so as to obtain the most efficient operation for the current level of inputs without changing them [32]. The output-oriented DEA model differs from the input-oriented one by minimizing the ratio of weighted inputs to weighted outputs [33].

The model is defined as shown in (5) and (6):

$$Enkg_j = \sum_{i=1}^{m} v_i x_i \qquad (5)$$

$$\sum_{r=1}^{n} u_r y_r = 1$$

$$-\sum_{r=1}^{n} u_r y_r + \sum_{i=1}^{m} v_i x_i \geq 0 \qquad (6)$$

$$u_r, v_i \geq 0$$

If a decison maker intends to decide on the efficiencies of decision points using the CCR method, it must apply the aforementioned model to all decision points, whether using input-orientation or output-orientation. When the constructed model is solved for each decision point, total efficiency measurements for each decision point will be obtained. A measurement of 1 indicates efficiency for the decision point, and a measurement of less than 1 indicates inefficiency for the decision point.

2.1.2. Banker-Charnes-Cooper (BCC) Model

The BCC model developed by Banker, Charnes, Cooper (1984) provides technical efficiency for a given scale and differentiates between technical and scale efficiencies under increasing, decreasing or constant returns to scale [34]. While the CCR model measures overall efficiency under constant returns to scale, the BCC model measures technical efficiency under variable returns to scale.

The BCC models are examined in two separate forms; input-oriented and output-oriented.Input-oriented BCC models strive for maximal movement toward the efficient frontier through proportional reduction of inputs, while output-oriented BCC models strive for maximal movement toward the efficient frontier through proportional augmentation of outputs.

The feasible solution region for BCC models is a subset of the solution region for CCR models. The relationship between the target values of CCR and BCC models is $\theta^b \geq \theta$. Consequently, a DMU found to be CCR-efficient will also be found to be efficient under the related BCC model. The only difference of the BCC model from the CCR model is that, under the variable returns to scale assumption, the total for the λ values, obtained as a result of solving the linear programming for each decision making unit, is equal to 1 (λ value: the value that provides information for efficient input and output combinations possible for an inefficient decision making point).

The model is defined as shown in (7) and (8).

Objective function:

$$Enk\ \Theta_k \qquad (7)$$

Constraints:

$$\sum_{j=1}^{N} y_{rj}\lambda_{jk} \geq y_{rk} \qquad (8)$$

$$\Theta_k x_{ik} - \sum_{j=1}^{N} x_{ij}\lambda_{jk} \geq 0$$

$$\sum_{j=1}^{N} \lambda_j = 1$$

2.1.2.1. Input-Oriented BCC Model

As was the case for the CCR model, the input-oriented BCC model also seeks the most feasible input combination that can most efficiently produce a specific combination of outputs. The proportional equations for input-oriented BCC models are provided in (9) and (10).

Objective function:

$$E_o = Max\left(\frac{\sum_{r=1}^{s} u_r y_{ro} - u_o}{\sum_{i=1}^{m} v_i x_{io}}\right) \qquad j=1,\ldots,n \qquad (9)$$

Constraints:

$$\frac{\sum_{r=1}^{s} u_r y_{rj} - u_0}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \qquad r=1,\ldots,p \text{ ve } i=1,\ldots,m$$

$$\frac{u_r}{\sum_{i=1}^{m} v_i x_{io}} \geq \varepsilon \qquad (10)$$

$$\frac{v_i}{\sum_{i=1}^{m} v_i x_{io}} \geq \varepsilon$$

Where:

u_o : Free (unrestricted) variable

2.1.2.2. Output-Oriented BCC Model

As was the case for the CCR models, the goal is the maximal output combination that can be obtained for a specific combination of inputs. The mathematical equations for output-oriented BCC models are provided in (11) and (12).

Objective function:

$$Min\theta_k = \sum_{i=1}^{m} v_i x_{ik} - \rho_o \qquad j=1,\ldots,n \qquad (11)$$

Constraints:

$$\frac{\sum_{i=1}^{m} v_i x_{ij}}{\sum_{i=1}^{s} u_r y_{rj}} \geq 1 \qquad r=1,\ldots,p \text{ ve } i=1,\ldots,m \qquad (12)$$

$$\sum_{r=1}^{s} u_r y_{rk} = 1$$

$$v_i \geq \varepsilon$$

$u_r \geq \varepsilon$

Where:

u_r : Weight attached to output r by decision unit o.

v_i : Weight attached to input i by decision unit o.

y_{ro} : Output r produced by decision unit o.

x_{io} : Input i used by decision unit o.

y_{rj} : Output r produced by decision unit j.

x_{ij} : Input i used by decision unit j.

ε : A sufficiently small positive number.

ρ_o :Variable marked as free.

Following a solution to the problem, the smallest value that E_o may have is 1. E_o being equal to 1 implies that decision unit o is efficient; a value higher than 1 implies the decision unit is inefficient.

2.2 Principal Component Anaysis (PCA)

Principal component analysis was first introduced by Karl Pearson in early 1900s. The formal approach to the method was conceived by Hotelling (1933) and Rao (1964). Principal component analysis can be used to convert a series of related p variables into uncorrelated hypothetical entities called principal components. Principal component analysis is used to reveal and interpret existing dependencies among variables, as well as to examine possible relationships among points. Principal component analysis can be used to stabilize predictions, evaluate multivariate normality and determine variances [1].

Farrar and Glauber, Haitovsky, Massy, Meyer and Kraft have applied the technique to problems in econometrics. In associated research, Rao provides examples where PCA can be beneficial in determining factors of dimension and shape. Girshick (1939) and Anderson (1958) have examined, and further developed, the distribution and sampling attributes of PCA. Morrison (1967) has researched geometric interpretation of principal components as well as their other attributes. Following the advent of computers, Cooley and Lohnes (1971) have conceived computer applications for PCA and have shown their practical uses. Additionally, they have demonstrated what forms the theoretical basis of principal component analysis using the generalized least squares method and eigenvalues (Abdel-Aziz, 1993: 2). A detailed discussion of the topic is provided by Jolliffe (1986), Jackson (1991) and Basilevsky (1994) [1].

Some of the practical uses of principal component analysis may be listed as follows: exploration of the correlation among variables in a given set; obtaining the minimum number of significant dimensions; reduction of the dimensions of a measured variance; exclusion from analysis those variables containing less information (contributing less); grouping of n-dimensional points in space; orthogonallization of measured calculations. These uses do not have equal significance in the study carried out; however, the method provides unique solutions for problems of types listed above using minimum assumptions, and is convenient to use because of its practical implementation through the use of software.

Using PCA, new variables Y_1, Y_2, …., Y_m are obtained which are independent of each other and where $m < p$; these variables are comprised of the linear components of the variables X_1, X_2 , ….., X_p.

While the entire system can be explained using p components, most of the information is attempted to be explained using a suitable number of m significant components, where $m < p$. This subset of m variables is newly obtained, with variables that fit as closely as possible the structure found in the original p variables. To determine this best-fit subset, the original variables are checked for the existence of variables that have a high degree of correlation. The variables with high correlation exhibit a close linear correlation.

2.2.1. Implementation Steps

A specific goal of principal component analysis is to summarize the observed correlation structure of the variables so as to reduce the high number of variables to entities that are fewer in number. Principal component analysis method is useful in expressing a high number of variables in the form of a small number of entities. Mathematically, principal component analysis defines an entity identifying each linear combination of the observed variables. These structures summarize the correlation structure of the observed correlation matrix and thus may be used in reconstructing the observed correlation matrix. As the number of components is much fewer than the number of observed variables, the results will be of a reliable nature.

Steps in conducting principal component analysis are as follows:

1) Selection and measurement of variable sets.

2) Construction of correlation matrices.

3) Derivationo f component sets from correlation matrices.

4) Determination of the number of components.

5) Interpretation of the results.

While most of these steps are mandatory from a statistical point of view, an important test for the analysis is whether it can be interpreted. Interpretation and naming of components depend on whether specific combinations of observed variables have a high degree of correlation with each component. A high number of observed variables having high correlation with any one of the components and such variables in turn exhibiting a significant amount of correlation with other components implies clear interpretability for that component.

2.2.2. Strengths and Weaknesses of Principal Component Analysis

The first weakness of the principal component analysis method is the lack of any criteria by which the solution may be tested against the variables.

The second weakness faced in principal component analysis is the infinite number of transformations that are possible following creation of the components. The final selection among the alternatives depends on the interpretation skills of the researcher. Existence of infinite number of mathematically identical solutions propels the researcher to find the best solution. As differences are not revealed through objective criteria, arguments for the best available solution may sometimes be difficult to explain.

The third weakness is that correlation coefficients tend to be less reliable when estimations are based on small sample sizes.Therefore, it is essential to work with a sufficiently large sample size for the correlations to be reliable.

The strength of principal components analysis method is in its ability to analyze all variations of the observed variables. The goal of principal components analysis is to maximize the variance with the help of orthogonal factors that are fewer in number than the data set. As there is no need for matrix transformations, multicollinearity does not pose a problem in principal component analysis. In principal components analysis, the choice of a solution depends on the agreement of the model, the data set and the goals of the research at hand. If an empirical summary of the data set is sought, principal component analysis will be a better choice. One of the more useful results of principal component analysis is the concept of component scores. Component scores are estimations of scores measured directly from each component.

3.Results and Analysis

3.1.Principal Component Analysis

NUTS Level 3 data used in the analyses was obtained from the Turkish Statistical Institute. The indicators used for the banking component were obtained from The Bank Association of Turkey. The most up-to-date versions of the data for all 81 provinces in Turkey were used. With a goal towards devising complete data sets, those indicators which did not include data points for all provinces were left out of the analyses.

Indicators included in analysis (Turkish Statistical Institute, 2013):

Foreign Trade Component (Model 1)

- ✓ Exports associated with economic activities (Thousand $)
- ✓ Imports associated with economic activities (Thousand $)

Labor Force Component (Model 2)

- ✓ Number of new ventures per employment records
- ✓ Unemployment ratio
- ✓ Employment ratio

Energy and Justice Component (Model 3)

- ✓ Total electricity consumption by final consumption categories (MWh)
- ✓ Number of penal instutions by type of detention

Transportation Component (Model 4)

- ✓ Number of motorized land vehicles (total)
- ✓ Number of traffic accidents
- ✓ Provincial and state roads (km)

<u>Education Component (Model 5)</u>

- ✓ Number of preschools
- ✓ Number of secondary education teachers
- ✓ Number of preschool teachers
- ✓ Number of preschool students
- ✓ Number of primary education teachers
- ✓ Number of primary education students
- ✓ Number of secondary education schools
- ✓ Number of secondary education students
- ✓ Number of schools (all education types)
- ✓ Number of teachers (all education types)
- ✓ Number of students (all education types)
- ✓ Number of vocational and technical education schools
- ✓ Number of vocational and technical education teachers
- ✓ Number of vocational and technical education students
- ✓ Number of students per teacher for primary education
- ✓ Number of students per teacher for secondary education
- ✓ Number of students per teacher
- ✓ Number of general students per teacher
- ✓ Number of vocational and technical education students per teacher
- ✓ Number of graduates from associate and undergraduate degree programs in institutions of higher education
- ✓ Number of students registered in associate and undergraduate degree programs in institutions of higher education
- ✓ Number of new registrations for associate and undergraduate degree programs in institutions of higher education

<u>Healthcare Component (Model 6)</u>

- ✓ Number of hospitals
- ✓ Number of practicing physicians
- ✓ Number of medical assistants

- ✓ Number of hospital beds
- ✓ Number of dental practitioners
- ✓ Number of nurses
- ✓ Number of specialist physicians
- ✓ Number of pharmacists
- ✓ Number of midwives

<u>Agriculture Component (Model 7)</u>

- ✓ Total cultivated land
- ✓ Land harvested for grains and other crops (hectares)
- ✓ Production volumes for grains and other crops (tonnes)
- ✓ Honey production (tonnes)
- ✓ Milk production (tonnes)
- ✓ Valuation of livestock (Thousand TL)
- ✓ Numbers of select farming equipment and machines

<u>Environment Component (Model 8)</u>

- ✓ Environment related expenditures of municipalities (TL)
- ✓ Daily per capita water drainage by municipalities (liter/person-day)

<u>Culture Component (Model 9)</u>

- ✓ Number of libraries
- ✓ Number of library patrons
- ✓ Number of material lent out
- ✓ Number of movie theaters
- ✓ Total movie audiences
- ✓ Number of movie theater seats
- ✓ Number of movie showings
- ✓ Number of theaters
- ✓ Total theater audiences
- ✓ Number of theater seats

- ✓ Number of theater shows

Banking Component (Model 10) (Retrieved on 27 November 2014 from: http://www.tbb.org.tr/tr/banka-ve-sektor-bilgileri/veri-sorgulama-sistemi/illere-ve-bolgelere-gore-bilgiler/73)

- ✓ Number of ATMs
- ✓ Number of POS (Points of Sale)
- ✓ Number of banking personnel
- ✓ Number of member businesses
- ✓ Total number of accounts
- ✓ Number of branches
- ✓ Total deposits (Thousand TL)
- ✓ Total credits issued (Thousand TL)

Population Component(Model 11)

- ✓ Population
- ✓ Out-of-provinces migration
- ✓ Number of villages
- ✓ Number of municipalities
- ✓ Population density
- ✓ Influx-to-provinces migration
- ✓ Total age dependency ratio

Housing Component(Model 12)

- ✓ Homeowner households (%)
- ✓ Home sales

The only complete and meaningful indicators available for energy and justice are as shown above; as these variables were deemed important enough not to be dismissed, they were lumped together into a single category created for the purpose.

The components produced using principal component analysis were observed to be in conformance with the indicator groups initially determined. Indicators for Education, Agriculture, Population and Culture were expressed by more than one principal component. The results of the principal component analysis are shown in Table 1 [35].

Table 1.Results of Principal Component Analysis

Indicator Groups	**KMO Sample Sufficiency**	**Bartlett's Test of Sphericity**		**Number of Components**	**Explanatory Power for Total Variance**
		Chi-Square (χ^2)	**P Value**		
Foreign Trade	0.500	362.971	0.000	1	99.754
Labor Force	0.507	49.395	0.000	1	56.733
Energy and Justice	0.500	81.220	0.000	1	90.145
Transportation	0.428	219.004	0.000	1	72.275
Education	0.852	6326.317	0.000	3	95.827
Healthcare	0.914	2615.812	0.000	1	97.521
Agriculture	0.814	638.987	0.000	2	82.918
Environment	0.500	1.154	0.283	1	56.041
Culture	0.863	2587.175	0.000	2	93.184
Banking	0.881	3028.119	0.000	1	98.768
Population	0.724	867.522	0.000	3	90.031
Housing	0.500	19.903	0.000	1	73.662

Examination of Table 1 reveals that the Kaiser-Meyer-Olkin (KMO) sample sufficiency values are larger than 0.5, thereby providing conformation that these variables are suitable for use in principal component analysis. Bartlett's Test of Sphericity indicates whether the relationships among the variables are significant. Reviewing the p values for the aforementioned test reveals that for all cases other than the indicator group for Environment, the p values are 0.000 (i.e. < 0.050) and that therefore, the existence of a significant relationship among the variables may be stated with a 0.95 probability. The highest explanatory power for total variance was determined for the Foreign Trade indicator group, at 99.8%, and the lowest such value was determined for the Environment indicator group at 56.0%. The study shows that the indicator group for Education has resulted in three principal components, Agriculture in two components, Culture in two components, and Population in three components.The detailed descriptions for the resulting components are provided in Table 2.

Table 2. Principal Components

Foreign Trade Component		**Environment Component**	
Variables	**Component 1**	**Variables**	**Component 1**
Imports associated with economic activities (Thousand $)	0.999	Environment related expenditures of municipalities (TL)	0.749
Exports associated with economic activities (Thousand $)	0.999	Daily per capita water drainage by municipalities (liter/person-day)	-0.749
Labor Force Component		**Banking Component**	
Variables	**Component 1**	**Variables**	**Component 1**
Employment ratio	-0.911	Number of branches	0.999
Unemployment ratio	0.907	Number of POS (Points of Sale)	0.998
Number of new ventures per employment records	0.905	Number of ATM	0.997
Energy and Justice Component		Total credits issued (Thousand TL)	0,994
Variables	**Component**	Number of member	0.992

	1	businesses	
Number of penal instutions by type of detention	0.949	Number of banking personnel	0.991
Total electricity consumption by final consumption categories (MWh)	0.949	Total deposits (Thousand TL)	0.989
		Total number of accounts	0.989
Healthcare Component		**Transportation Component**	
Variables	**Component 1**	**Variables**	**Component 1**
Number of pharmacists	0.995	Number of traffic accidents	0.978
Number of nurses	0.995	Number of motorized land vehicles (total)	0.929
Number of hospital beds	0.995	Provincial and state roads (km)	0.590
Number of practicing physicians	0.993	**Housing Component**	
Number of specialist physicians	0.992	**Variables**	**Component 1**
Number of dental practitioners	0.989	Homeowner households (%)	0.858
Number of midwives	0.978	Home sales	-0.858
Number of hospitals	0.978		
Number of medical assistants	0.972		

As a result of the study, there are four groups of indicators for which more than one principal component were generated; the detailed information for these groups are provided in Table 3, Table 4, Table 5 and Table 6.

Table 3. Components for Education

Components for Education				
Variables	**Componen**	**Componen**	**Componen**	**Explained**

	t 1	t 2	t 3	Variation Percentage
Number of secondary education teachers	0.984			61.2
Number of schools (all education types)	0.982			
Number of teachers (all education types)	0.981			
Number of vocational and technical education teachers	0.978			
Number of vocational and technical education students	0.978			
Number of preschool teachers	0.978			
Number of primary school teachers	0.977			
Number of vocational and technical education schools	0.971			
Number of students (all education types)	0.970			
Number of preschool students	0.967			
Number of secondary education students	0.965			
Number of primary education students	0.957			
Number of preschool schools	0.949			
Number of secondary education schools	0.944			
Number of students per teacher		0.980		20.7
Number of general students per teacher		0.926		
Number of students per teacher for primary education		0.908		
Number of students per teacher for vocational and technical education		0.905		
Number of students per teacher for secondary education		0.903		
Number of students registered in associate and undergraduate degree programs in			0.997	13.9

institutions of higher education				
Number of graduates from associate and undergraduate degree programs in institutions of higher education			0.971	
Number of new registrations for associate and undergraduate degree programs in institutions of higher			0.944	

As can be concluded from Table 3, the indicator group for Education is expressed in terms of three principal components. The table also shows the weights of the variables for each of the principal components. If the principal component weight is negative, an inversely proportional relationship exists, and if the weight is positive, a directly proportional relationship exists. Per the aforementioned weights, the weighted factors defining the Education component may be seen in the same table. Finally, having an explained variation percentage value of 61.2% by itself, the first principal component explains the Education component.

Table 4. Components for Population

Components for Population				
Variables	**Component 1**	**Component 2**	**Component 3**	**Explained Variation Percentage**
Out-of-provinces migration	0.988			54.9
Population	0.987			
Influx-to-provinces migration	0.979			
Population density	0.958			
Number of villages		0.849		18.7
Number of		0.726		

municipalities				
Total age dependency ratio			0.915	16.4

As a result of PCA, the indicator group for Population is expressed in terms of three principal components, shown in Table 4. Having an explained variation percentage value of 54.9% by itself, the first principal component has the highest explanatory power. The variable for total age dependency ratio has generated a principal component by itself, and explains 16.4% of the variance.

The indicator group for Culture is expressed in terms of two principal components, shown in Table 5. Having an explained variation percentage value of 69%, the first component can explain the indicator group by itself.

Table 5. Components for Culture

Components for Culture			
Variables	**Component 1**	**Component 2**	**Explained Variation Percentage**
Total movie audiences	0.973		69.0
Number of movie showings	0.973		
Number of movie theaters	0.972		
Number of theater shows	0.972		
Number of movie theater seats	0.971		
Number of theatres	0.959		
Total theater audiences	0.959		
Number of theater seats	0.936		

Number of library patrons		0.922	24.1
Number of material lent out		0.907	
Number of libraries		0.802	

Table 6. Components for Agriculture

Components for Agriculture			
Variables	**Component 1**	**Component 2**	**Explained Variation Percentage**
Production volumes for grains and other crops (tonnes)	0.948		66.1
Total cultivated land	0.919		
Land harvested for grains and other crops (hectares)	0.914		
Valuation of livestock (Thousand TL)	0.882		
Honey production (tonnes)	0.804		
Numbers of select farming equipment and machines	0.791		
Milk production (tonnes)		0.917	16.8

As seen in Table 6, the indicator group for Agriculture is expressed in terms of two principal components. The variable for milk production has generated the second principal component by itself, and has an explained variation percentage value of 16.8%. The variable for the production volumes for grains and other crops is observed to be the next most significant indicator.

At this stage of the study, ranking is provided for the provinces per principal component scores. When obtaining scores for principal components, scores obtained through regression have been used for those cases where only a single component was available. However, for four components (Education, Population, Culture and Agriculture; Tables 3, 4, 5 and 6, respectively) the component scores, obtained separately through regression, were weighted with eigenvalues and the weighted components were summed to obtain total component scores.

The province ranking first according to the Foreign Trade component is Istanbul, and the province ranking last is Tunceli. When considering the import and export capacities of these two provinces, the results are credible.

The province ranking first according to the Labor Force component is Şırnak, and the province ranking last is Ardahan. This outcome is due to the ratio of unemployment being the most significant indicator for the Labor Force component, which, for Şırnak, stands at 15.3%.

The province ranking first according to the Energy and Justice component is Istanbul, and the province ranking last is Bayburt. While there are 21 penal institutions located in Istanbul, there is one located in Bayburt.

The province ranking first according to the Transportation component is Istanbul, and the province ranking last is Kilis.

For the Education component, Istanbul again ranks first and Tunceli ranks last.

For the Health Care component, Istanbul ranks first and Bayburt ranks last.

For the Agriculture component, Konya ranks first and Yalova ranks last. The most significant indicator for the Agriculture component, that of production volumes for grains and other crops, has a value of 1,904,439 hectares, while the same indicator for Yalova is only 12,796 hectares. Konya is in the lead similarly for the remaining indicators for the Agriculture component.

For the Environment component, Istanbul ranks first and Yalova again ranks last.

For the Culture component, Istanbul ranks first and Kilis ranks last.

For the Banking component, Istanbul again ranks first and Bayburt ranks last.

For the Population component, Istanbul ranks first and Tunceli ranks last.

Finally, for the Housing component, Ardahan ranks first and Istanbul ranks last. The reason for this surprising result for the Housing component is the fact that the percentage indicator for households who are home owners is weighted for this component. At 84.31%, Ardahan leads all of Turkey for the leading number of home owner households.

3.2. Data Envelopment Analysis

In the efficiency analyses conducted using DEA, it is of significant importance to specify the inputs used and the outputs produced by the decision units, as any changes that are made to the selected inputs and outputs will lead to disparate efficiency results [5]. This is more of a concern for those models with a high number of inputs and outputs. The list of inputs and outputs selected for the study is given in Table 7 [35].

Table 7. Inputs and Outputs Used in Analysis

Dimension	Variable	Input / Output
Foreign Trade	Imports associated with economic activities (Thousand $)	**Input**
	Exports associated with economic activities (Thousand $)	**Output**
Labor Force	Number of new ventures per employment records	**Input**
	Unemployment ratio	
	Employment ratio	**Output**
Energy and Justice	Number of penal instutions by type of detention	**Input**
	Total electricity consumption by final consumption categories	**Output**
Transportation	Number of motorized land vehicles	**Input**
	Number of traffic accidents	
	Provincial and state roads	**Output**
Environment	Environment related expenditures of municipalities	**Input**
	Daily per capita water drainage by municipalities	**Output**
Housing	Home sales	**Input**
	Homeowner households	**Output**
Health Care	Number of hospital beds	**Input**
	Number of practicing physicians	
	Number of medical assistants	
	Number of nurses	

	Number of midwives	
	Number of hospitals	
	Number of specialist physicians	**Output**
	Number of dental practitioners	
	Number of pharmacists	
	Numbers of select farming equipment and machines	**Input**
	Total cultivated land	
	Land harvested for grains and other crops (hectares)	
	Production volumes for grains and other crops (tonnes)	
Agriculture	Milk production	**Output**
	Honey production	
	Valuation of livestock	
	Total deposits	
	Number of preschool teachers	
	Number of preschool students	
	Number of primary education teachers	
	Number of primary education students	
Education	Number of secondary education teachers	
	Number of secondary education students	**Input**
	Number of teachers (all education types)	
	Number of students (all education types)	
	Number of vocational and technical education teachers	
	Number of vocational and technical education students	
	Number of students per teacher for primary education	
Education	Number of students per teacher for secondary education	**Input**
	Number of students per teacher	
	Number of students per teacher for vocational and technical education	
	Number of students registered in associate and	

	undergraduate degree programs in institutions of higher education	
	Number of new registrations for associate and undergraduate degree programs in institutions of higher education	
Education	Number of preschools	**Output**
	Number of secondary education schools	
	Number of schools (all education types)	
	Number of vocational and technical education schools	
	Number of students per teacher	
	Number of graduates from associate and undergraduate degree programs in institutions of higher education	
Population	Influx-to-provinces migration	**Input**
	Out-of-provinces migration	
	Population density	
	Population	**Output**
	Number of municipalities	
	Number of villages	
	Total age dependency ratio	
Culture	Number of material lent out	**Input**
	Number of movie theater seats	
	Number of movie showings	
	Total movie audiences	
	Number of theater seats	
	Number of theater shows	
	Total theater audiences	
	Number of libraries	**Output**
	Number of library patrons	
	Number of movie theaters	
	Number of theaters	

Banking	Number of ATMs	**Input**
	Number of POS (Points of Sale)	
	Number of member businesses	
	Number of banking personnel	
	Number of branches	
	Total number of accounts	
	Total credits issued	**Output**
	Total deposits	

The models initially devised have been solved through the application of output-oriented CCR and BCC models. Using the analysis carried out with the determined inputs and outputs, efficiency ranking for 81 provinces have been performed, and reference units have been created for the inefficient provinces. It is a given that the number of efficient units obtained from a BCC solution is greater than that for a CCR solution. Therefore, a CCR model produces more realistic results.

The pivotal point to take into account when interpreting the results of the model is that the efficiency results reflect only the relative efficiency values. That is, a 100% efficiency outcome value for a province is only valid against the other provinces it has been compared with, and only within the scope of the outputs. The result should not be taken to mean that the province in question would be 100% efficient in its usage of resources when considered by itself [4].

It can be observed that according to output-oriented CCR Foreign Trade efficiency score ranking, the Şırnak province is relatively efficient and the Giresun province, for which Şırnak is the reference province, is closest to efficiency in relative terms; the Tunceli province is observed to be furthest away from efficiency.This outcome should be interpreted to mean that the relatively inefficient province uses its resources (those included in the study) in a relatively inefficient manner compared to the province or provinces which are relatively more efficient than itself.This is the primary reason why the province in question is found to be inefficient.

When required, data envelopment analysis can identify for the researchers the inefficiently used resources and the degree to which an improvement is needed; however, this is beyond the scope of this study.

For the Labor Force efficiency score ranking, it was determined that Kastamonu and Bayburt provinces are relatively efficient and that the Ardahan province is closest to efficiency in relative terms; the Diyarbakır province is observed to be furthest away from efficiency.

For the Energy and Justice super efficiency score ranking, it was determined that the Istanbul province is relatively efficient and that the Kocaeli province is closest to efficiency in relative terms; the Kilis province is observed to be furthest away from efficiency.

For the Transportation efficiency score ranking, it was determined that the Tunceli province is relatively efficient and that the Hakkari province is closest to efficiency in relative terms; the Istanbul province is observed to be furthest away from efficiency.

For the Education super efficiency score ranking, 74 provinces are observed to be relatively efficient. The remaining provinces may achieve relative efficiency, if the reference values are taken into account.

For the Health Care super efficiency score ranking, 21 provinces are observed to be relatively efficient.

For the Agriculture super efficiency score ranking, the Rize and Adıyaman provinces are observed to be relatively efficient.

For the Environmentsuper efficiency score ranking, the Kütahya province is observed to be relatively efficient.

For the Culture super efficiency score ranking, 68 provinces are observed to be relatively efficient.

For the Banking super efficiency score ranking, it was determined that Istanbul, Gaziantep, Ankara and Hatay provinces are relatively efficient and that the Kahramanmaraş province is closest to efficiency in relative terms; the Trabzon province is observed to be furthest away from efficiency.

For the Population super efficiency score ranking, 24 provinces are observed to be relatively efficient.

For the Housing super efficiency score ranking, only one province, Ardahan, is observed to be relatively efficient.

It can be observed that according to output-oriented BCC Foreign Trade super efficiency score ranking, Istanbul, Şırnak and Kocaeli provinces are relatively efficient and that the Bursa province is closest to efficiency in relative terms; the Tunceli province is observed to be furthest away from efficiency.

For the Labor Force super efficiency score ranking, it was determined that Bayburt, Kastamonu and Ardahan provinces are relatively efficient and that the Artvin province is closest to efficiency in relative terms; the Kırıkkale province is observed to be furthest away from efficiency.

For the Energy and Justice super efficiency score ranking, it was determined that Istanbul, Yalova and Zonguldak provinces are relatively efficient and that the Kocaeli province is closest to efficiency in relative terms; the Batman province is observed to be furthest away from efficiency.

For the Transportation super efficiency score ranking, it was determined that Konya, Tunceli and Sivas provinces are relatively efficient and that the Kastamonu province is closest to efficiency in relative terms; the Düzce province is observed to be furthest away from efficiency.

For the Education super efficiency score ranking, 75 provinces are observed to be relatively efficient.

For the Health Care super efficiency score ranking, 26 provinces are observed to be relatively efficient.

For the Agriculture super efficiency score ranking, 12 provinces are observed to be relatively efficient.

For the Environment super efficiency score ranking, it was determined that Ardahan and Yalova provinces are relatively efficient and that the Kırşehir province is closest to efficiency in relative terms; the Kilis province is observed to be furthest away from efficiency.

For the Culture super efficiency score ranking, 73 provinces are observed to be relatively efficient.

For the Banking super efficiency score ranking, 7 provinces are observed to be relatively efficient. Aksaray and Karaman are closest to efficiency in relative terms and the Trabzon province is observed to be furthest away from efficiency.

For the Population super efficiency score ranking, 32 provinces are observed to be relatively efficient.

For the Housing super efficiency score ranking, Hakkari and Ardahan provinces are relatively efficient.

An examination of the data provided above indicates that the BCC model results are more optimistic when compared with the CCR model results.

The province rankings performed using principal component analysis and data envelopment analysis were tested using Spearman Rank Correlation. Accordingly, the Spearman Rank Correlation significance level (P) value was found to be less than the 5% significance level for the dimensions of Labor Force, Transportation, Energy and Justice, Environment, Agriculture, Housing and Banking. That is, the rankings for these dimensions obtained using two separate analyses were found to be related. However, the Spearman Rank Correlation values were calculated as negative for the Energy and Justice, Banking and (partially) Agriculture dimensions. That is, the rankings were inversely proportional for the aforementioned dimensions. A province ranking first in one analysis was found to rank last in the other analysis. The Spearman Rank Correlation values for the other dimensions are positive. That is, it was found that the rankings are similar in the two analyses [35].

4. Conclusion (10pt)

The primary goal of the study was to measure the relative efficiencies of provinces using data envelopment analysis. Principal component analysis was also employed. Towards the stated goal, the first stage of the study carried out factoring using principal component analysis with NUTS Level 3 data; then the data was expressed in the form of 12 principal components. Ranking of the provinces was carried out using component scores. The said ranking was found to be in line with the expectations. Some of the verified expectations include the largest provinces of Turkey (Istanbul, Ankara and İzmir) placing at the top for the ranking in Foreign Trade, and the leading agricultural province of Konya placing at the top for the ranking in Agriculture.

As part of data envelopment analysis, output-oriented CCR and BCC models were applied. The results were obtained using the super efficiency method. The study examined how efficiently provinces used their resources and to what degree they were able to convert their resources into value added products. The important point to consider is that the measured efficiency for a province is not its stand-alone efficiency, but its relative efficiency. When an efficient province in question is measured anew as part of a different group, using different input and output groups, it may come out as inefficient; and conversely, an inefficient province may come out as efficient. Analyses indicate that the BCC model results are more optimistic when compared with the CCR model results. Literature review reveals that the CCR model is preferred for obtaining more realistic results. To compare the results from the data envelopment analysis and the principal component analysis activities, Spearman Rank Correlation test was applied, and statistically significant relationships were found among seven dimensions (Labor Force, Energy and Justice, Transportation, Environment, Agriculture, Housing and Banking).

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