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EVALUATION OF REGIONAL DEVELOPMENT WITH BANKING AND FINANCE DATA

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Abstract: This research aims to measure the change of provincial development levels of Turkey's 81 provinces through banking sector data. The applied methodology is the Malmquist Total Factor Productivity Index (MTFPI). We perform the analysis based on two models. The main difference between models relies on handling the factor associated with 'loans'. The first approach sees the loans as an output factor, which is based on the idea that loans indicate investment and therefore development. In the second model, we take the loans as an input factor, which represents the idea that loans indicate debt and therefore they should be minimized. We evaluate the findings with respect to geographical classification and the province development index.

Key Words: *regional development, banking system, data envelopment analysis, Malmquist Total Factor Productivity Index.*

Introduction

Measuring regional development levels is important in shaping micro and macro planning. Such measurements can provide insight on what to be prioritized in policies or investments while generating long-term development plans, as well as, it is possible to identify potential allocation areas for the resources and funds in the short-term. Having an idea on the level of financial, intellectual and environmental development at the regional level is beneficial for identifying reference provinces and preparing improvement policies for the undeveloped ones. Accordingly, various research can be found that evaluate the financial, intellectual and environmental aspects of regional development at the provincial level. The studies address a variety of issues, such as: identifying how effective the resources of provinces are used (Giffinger et al. 2007, Ulucan and Atıcı 2010, Giffinger and Haindlmaier 2010, Raźniak et al. 2015); evaluating life quality in order to position the well-being of countries on a provincial basis (Zhu 2001, Morais and Camanho 2011, Carboni and Russu 2015); determining the level of provinces in terms of planning services (Lahdelma et al. 2002, O'Connor 2010); assessing environmental development (Hanson et al. 2011, Sheng and Tang 2016); evaluating intellectual development (López-Ruiz et al. 2014, Nitkiewicz et al. 2014); and the measurement of competitiveness among provinces (Kourtit et al. 2013, Singhal et al. 2013a, Singhal 2013b).

Regional development is highly associated with regional prosperity. For measuring the level of prosperity (therefore development) in a given region, the banking data, as well as the economic indicators, can play a key role since they have the potential to give an idea on the financial structure of the region. Such data can reveal how the money is distributed between deposits and loans, which indirectly provides insight on the financing of the investments within the region. Provincial-level evaluations using economic indicators (such as employment level, tax revenues, imports, exports, size of the manufacturing industry in the given region, etc.) is very common in evaluating regional development levels.

In this research, we aim to incorporate a financial perspective to such evaluations using the banking data of the provinces together with other indicators. The banking data used in this study include different types of loans (personal, sectoral and non-cash sectoral loans) given out

by the bank branches and deposits (deposits and foreign exchange deposits) in the branches at provincial level. Together with indicators such as employment, participation rate in the labor force, imports, exports and several indicators on investors, we aim to come up with a multi-dimensional measure of regional development with respect to the economic and financial structure in 81 provinces of Turkey to reflect the level of prosperity as well. The analysis is intending to evaluate the period following the 2008 crisis for which there exists a prevalent claim that the Turkish financial sector has experienced the effects of this crisis less severely than the western economies (Yörükoğlu and Atasoy 2010, Kibritci Artar and Atilgan Saridoğan 2012).

Data Envelopment Analysis (DEA) is a widely used methodology to evaluate relative performance in the presence of multiple dimensions (input and output) in the intended evaluations. It is a non-parametric method applied in both micro and macroeconomic levels since its introduction by Charnes et al. (1978). DEA provides a relative measurement of efficiency for the evaluated units. This is done by comparing the evaluated unit's performance with an efficient frontier using linear programming. In its standard use, the method measures the relative efficiency at a point in time. Because it is a relative measure, the efficiency measured at one point in time is relative to the given period's frontier. When the evaluation period changes, the frontier also changes and, therefore, the efficiency measure in a given period may not be comparable with the next period's measure. Building upon these facts on the DEA measures, the Malmquist Total Factor Productivity Index (MTFPI) has been developed (Caves et al. 1982, Färe et al. 1992) to measure the changes over time by considering both changes in efficiency and the shift on the frontier from one period to another.

Our evaluations intend to involve the handling of multiple indicators as well as multiple periods (2009-2014). Therefore, in measuring the provincial level financial performance, we use DEA and MTFPI to observe the movement of the measures over time. With the use of these methods, the efficiency score of each province and its change over time are measured relative to all other provinces. We interpret the findings relying on the existing measure of the Provincial Development Index (PDI) developed by Gül and Çevik (2015), classifying the provinces of Turkey into 5 clusters relying on their development level. Regarding the model design, we undertake the problem with two main approaches. The main difference between these two approaches relies on handling the factor associated with 'loans'. The first approach sees the loans as an output factor, which relies on the idea that loans indicate investment and therefore development. On the contrary, in the second model, we take the loans as an input factor, which relies on the idea that loans indicate debt and therefore they should be minimized.

The current research evaluates the provincial development levels in Turkey and its change over the years followed by the 2008 crisis, leaning on the idea that banking data can provide additional perspective (regarding prosperity) to the assessment of regional development. Commonly used economic factors are not ignored during evaluations, and instead, banking sector data is articulated into conventional variables, resulting in a comprehensive look at regional development. Inserting new dimensions to the problem enabled us to interpret the provinces' development level from a different angle, by discussing the provincial-level results concerning the current classification regarding development. This provides us to observe how the provinces that are currently identified as developed or underdeveloped perform with respect to the models involving both economic and financial criteria. The results may reveal potential improvement areas and the provinces that require attention in managing regional development. The findings are also interpreted concerning the GDP change during the same period, which reveals a similar pattern in one of the approaches.

The paper is organized as follows: Section 2 presents the basics of the DEA and MTFPI methodologies. Section 3 is devoted to empirical application. We introduce the data set, discuss the model design and present the findings in this section. Finally, Section 4 concludes.

Methodology

The Malmquist Total Factor Productivity Index (MTFPI) is a Data Envelopment Analysis (DEA) based approach that allows the efficiency measurement over a certain period (Malmquist 1953, Caves et al. 1982, Färe et al. 1992). MTFPI measures the change in total factor productivity between two data points by calculating the ratios of the differences of each data point relative to the efficient frontiers of production technologies in each period. The distance function is used for the measurement. It is a nonparametric measure of productivity change which also contains information about the source of this change. The index represents the magnitude of improvement (or decrease) in the productivity of the evaluated unit from period t to $t+1$. The calculation of the index relies on the evaluation of the unit in both periods c and $t+1$ followed by cross evaluations of each period's performance within the data of the other period by making use of the fundamental CCR DEA model developed by Charnes et al. (1978). To calculate the MTFPI for each unit, DEA linear programs should be solved.

Let us consider n decision-making units. We assume that each decision-making unit j for $j = 1,2,\ldots,n$ uses m different inputs x_{ij}. For $i = 1,2,\ldots,m$ and it produces s different outputs. Y_{rj} For $r = 1,2,\ldots,s$. Let ϕ represent the efficiency score for unit o. Variables λ_j are introduced corresponding to each decision-making unit ($i = 1,2,\ldots,m$)to form a Production Possibility Set (PPS) consisting of observed units, their convex combinations, scaled units (because the constant returns to scale are assumed) and outperformed units. The units on the boundary (frontier) of the PPS are defined as efficient and they attain the efficiency score of 100%, where the efficiency scores for others are measured relative to the frontier. The linear programming formulation to calculate the efficiency score of unit o is given below:

$$
\begin{aligned}
&Max\ \phi && && (1)\\
&s.t. && &&\\
&\textstyle\sum_{j=1}^{n}\lambda_j x_{ij} \le x_{io} && i = 1,2,\ldots,m &&\\
&\textstyle\sum_{j=1}^{n}\lambda_j y_{rj} \ge \phi y_{ro} && r = 1,2,\ldots,s &&\\
&\lambda_j \ge 0 && j = 1,2,\ldots,n &&
\end{aligned}
$$

In general, DEA models provide the efficiency measurement at a point in time. Let

$$D_o^t(x^t, y^t) = \phi$$

In order to measure the change from one period to another, the MTFPI is calculated for each unit. MTFPI consists of two components as Efficiency Change and Technological Change. Efficiency Change refers to the ratio of efficiency score in period $t+1$ to the efficiency score in period t. This measure itself is not enough to identify the change in productivity from one period to another because these scores are relative to different frontiers. Therefore, it is essential to measure the change in the frontier from one period to another. This is the second component of the MTFPI, known as technological change. The calculation of Efficiency Change (EC) and Technological Change (TC) components for a unit are given below:

$$EC = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \quad (2)$$

$$TC = \left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})}\right) * \left(\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right)\right]^{1/2} \quad (3)$$

Once both components are calculated relying on the linear programs, the MTFPI of a unit is calculated as given below (given as $M_O(x^{t+1}, y^{t+1}, x^t, y^t)$ to represent the change from period t to $t+1$.

$$M_O(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}\right)\left(\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right)\right]^{1/2} \quad (4)$$

Data Envelopment Analysis (DEA) and related methodologies such as Malmquist Total Factor Productivity Index (MTFPI) can be counted in the commonly used methods to measure the relative performance of provinces regarding regional development. MTFPI enables the application of DEA in multiple periods. Among the accounted research above, several DEA and its associate methods (e.g. Super Efficiency, Fuzzy DEA, Malmquist Total Factor Productivity Index) have been applied to different types of provincial data to come up with identifying efficiency levels as well as a ranking of the provinces (for examples, see Zhu 2001, Giffinger and Haindlmaier 2010, Ulucan and Atıcı 2010, Morais and Camanho 2011, Kourtit et al. 2013, Nitkiewicz et al. 2014, Carboni and Russu 2015, Wang et al. 2016, Chen 2017, Li et al. 2017, Li et al. 2018, Deilmann et al. 2018, Cao et al. 2019).

Banking is one of the major areas where DEA and MTFPI are also applied (some examples include Paradi and Schaffnit 2004, Thoraneenitiyan and Avkıran 2009, Paradi et al. 2011, Piot-Lepetit and Nzongang 2014, Alves et al. 2020, Christopoulos et al. 2020). DEA is also used to evaluate the performance of financial institutions (Sufian 2008, Cummins et al. 2010) and micro -finance institutions (Gutiérrez-Nieto et al. 2009, Biener and Eling 2011, Bassem 2014).

Results

Data

In measuring the regional development at provincial-level in Turkey, we undertook 16 variables (input and output factors). The set of factors involves economic indicators (such as employment level, tax revenues, imports, exports, size of the manufacturing industry in the given region, etc.) which are very common in evaluating the regional development levels. We benefited from the previous literature while identifying these variables (Atan et al. 2004, Düzakın 2009, López-Ruiz et al. 2014, Nitkiewicz et al. 2014, Piot-Lepetit and Nzongang 2014, Carboni and Russu 2015). Within the scope of the research, we aim to incorporate a financial perspective to the evaluations using the banking data of the provinces together with other indicators. Therefore, the set of factors also includes factors from the banking sector in the provinces of Turkey. All factors used in the study are explained below.

The factors related to the labor force (Turkish Statistical Institute 2016):

- *Participation Rate in Labor Force* represents the total number of people participating in the labor force in provinces between 2009 and 2014.

- *Employment Rate* represents the total number of employees hired in provinces between 2009 and 2014.

The factors related to the manufacturing industry (Turkish Ministry of Science, Industry and Technology).

- *Number of Workplaces in Manufacturing Industry* refers to the total number of active firms in the period of 2009-2014.
- *Net Sales in Manufacturing Industry* refers to net sales of firms (in Turkish Liras) by the end of the year between 2009-2014.

The factors related to the banking sector (Banking Regulation and Supervision Agency 2016):

- *Personal Loans* are cash credits used by individuals. It includes personal finance credit, vehicle loan, commercial personal finance credit, and mortgage loan.
- *Sectoral Loans* are cash loans provided for small, medium and large-sized commercial enterprises for commercial goods and services purchase as their legal entity.
- *Deposits* are bank accounts that contain money deposited to withdrawn at any time or the end of a specific term or notice. This variable refers to the sum of all types of deposit accounts (Turkish Lira) in banks of provinces.
- *Foreign Exchange Deposit (FED) Account* refers to the sum of all foreign exchange deposit accounts in banks of provinces. (Measured in Turkish Lira conversion).
- *Total TL+FED* refers to the sum of all accounts in banks of provinces (measured in US Dollars).
- *Non-Cash Sectoral Loans* are bank's credit facility by giving guarantee and bail in favor of legal entities and appropriate credits for the sector of legal entities with the aim that they could sustain their import and export activities. Letter of guarantee, external letter of guarantee and letter of credits are included in this loan group.

The factors related to investment potentials (Central Registry Agency 2016):

- *The number of Investors* refers to the number of individual investors registered in a certain province and transacting in the stock market.
- *Total Account Balance* refers to the total account balance amount of individual investors registered in a certain province and transacting in the stock market.

The Factors associated with contribution foreign trade (Turkish Statistical Institute 2016):

- *Import* represents total annual import activities carried out in provinces (measured in Turkish Liras).
- *Export* represents total annual export activities carried out in provinces (measured in Turkish Liras).

Other Factors:

- *Tax Revenues* represent the provincial-based tax revenues (in Turkish Liras). We acquire data from the Turkish Revenue Administration (2016).
- *Energy Consumption* expresses the total electrical energy consumed throughout a year in provinces as MWh. It measures the total electricity consumption of both industry and household in the provinces. The data source is the Turkish Statistical Institute.

Note that the factors associated with banking cover three main types of banks operating in Turkey: Deposit Banks, Participation Banks (Interest-free banks) and Development & Investment Banks. All categories include sub-categories as public, private and foreign banks. The data is collected from the database of the Banking Regulation and Supervision Agency of

Turkey at provincial level for all types.

Findings

We establish two models in handling the factors listed above. The controversy is related to the factors related to 'loans'. We approach these variables from two perspectives. The first approach looks at the loans as an output factor, which relies on the idea that loans indicate investment and therefore development. On the contrary, in the second model, we capture the loans as input factors, relying on the idea that loans indicate debt and therefore they should be minimized. This means that for loans, we have "*the more is better*" in one model and "*the less is better*" in another, respectively. Hence, we consider the factors associated with loans in our models as proxies of investment or indebtment in the given region. Below, we provide the findings of both models.

Model 1: Loans as Outputs

The model includes 9 outputs and 7 inputs that 81 provinces and the data from 2009-2014. Inputs and outputs used in the analysis are given in Table 1. Scores for each province are presented in Table A1 of the Appendix.

Fig. 1 presents the movement of the Malmquist Total Factor Productivity Index (MTFPI) over years together with its components. The MTFPI moves along with the technological change component in the period of 2009-2014. 2009-2010 is the most progressive period, while the most decrease is observed in the 2011-2012 period. The efficiency change component is more stable, in general. This shows that the changes in MTFPI are mostly caused by the shift in the investment environment (represented by technological change), rather than the individual changes in the financial structure of provinces (that can be embodied by the efficiency change component). Taking 2009 as the base year, the relationship between technological change and MTFPI can also be observed in Table 2. While the efficiency change component decreases

Table 1

Input and Output Factors for Model 1

Inputs	Outputs
Participation Rate in Labor Force	Personal Loans
Employment Rate	Sectoral Loans
Number of Workplace in Manufacturing Industry	Deposits (Turkish Lira)
Net Profit In Manufacturing Industry	Deposits (Foreign Exchange)
Import	Total Deposits
Export	Non-Cash Sector Loans
Energy Consumption	Tax Revenues
	The Number of Investors
	Total Account Balance

with the rate of 1% between the years of 2009-2014, the technological change component increases by 76%, resulting in a 75.4% increase in total productivity.
Since it is observed that technological change is dominant in increasing the total productivity, it is reasonable to observe its relationship with the GDP growth in the country over the given period. Fig. 2 presents the GDP Increase with MTFP. Generally, the GDP increase rate of

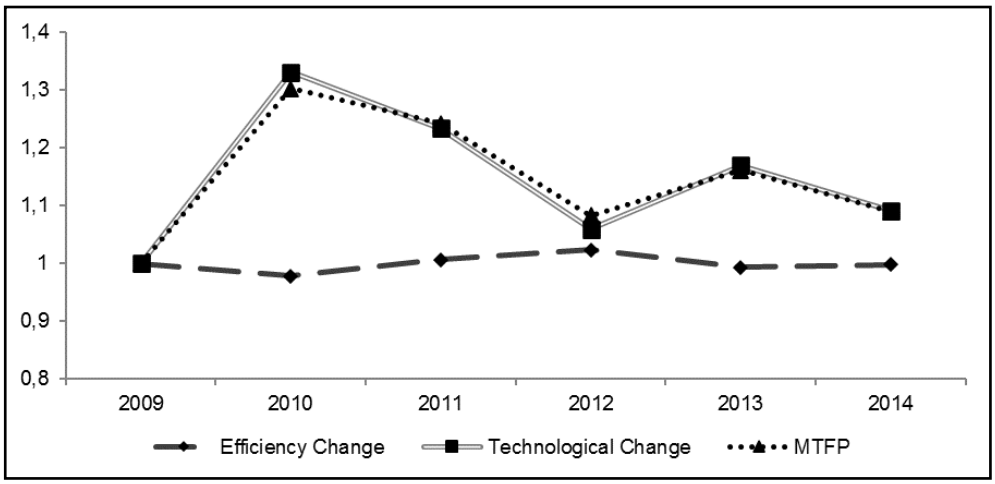

Fig. 1 - **MTFP Change by Year (Model 1)**

Turkey and the total factor productivity change seem to be parallel with each other. This is a sign that economic growth over the given period has a reflection on local development.

Fig. 3 shows the change in total factor productivity based on PDI. The results are interesting. Between 2002 and 2014, category 5, which consists of the least developed provinces, exhibit the largest progress. Category 4 has also experienced growth between 2010 and 2011. The

Table 2

Change in Cumulative Efficiency by Years (Model 1)

Years	Efficiency Change	Technological Change	Total Factor Productivity
2009	1	1	1
2010	0.978	1.331	1.302
2011	0.984	1.642	1.617
2012	1.006	1.739	1.751
2013	0.999	2.033	2.033
2014	0.997	2.218	2.214
Geometric Mean	**0.993**	**1.765**	**1.754**

least progress is observed in the most developed category. These findings may indicate that the growth in the post-crisis period seems to be deployed at different levels throughout the country. It is observed that the categories with the least developed provinces (category 4 and category 5) experience a noticeable growth relative to the other categories.

Model 2: Loans as Inputs

The model includes 6 outputs and 10 inputs of 81 provinces and the data from 2009-2014. The inputs and outputs used in the analysis are given in Table 4. The scores for each province are presented in Table A2 of the Appendix.

Fig. 4 presents the movement of the Malmquist Total Factor Productivity Index (MTFPI) over the years based on Model 2 together with its components. The largest fluctuation has been

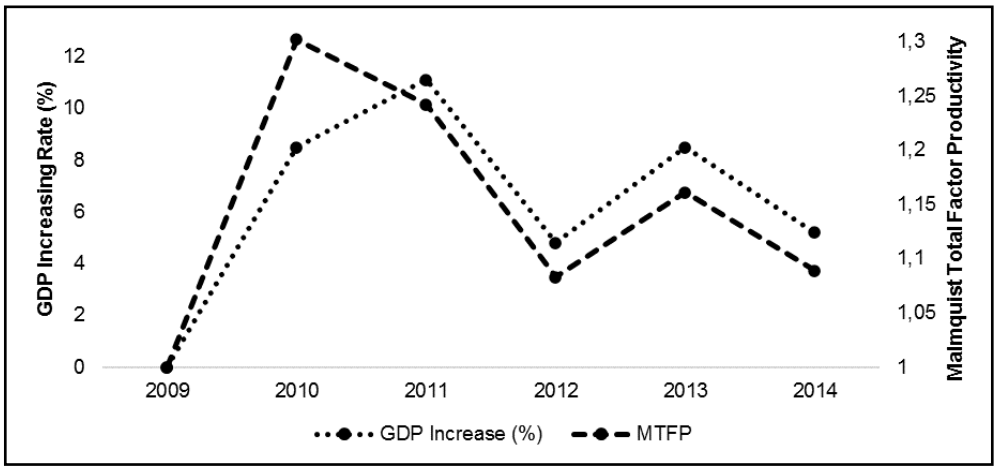

Fig. 2 - **GDP Growth Rate and Comparative MTFPI Chart (Model 1)**

Table 3

Province Classification of PDI

	Category 1	Category 2	Category 3	Category 4	Category 5
# of Provinces	6	17	27	14	17

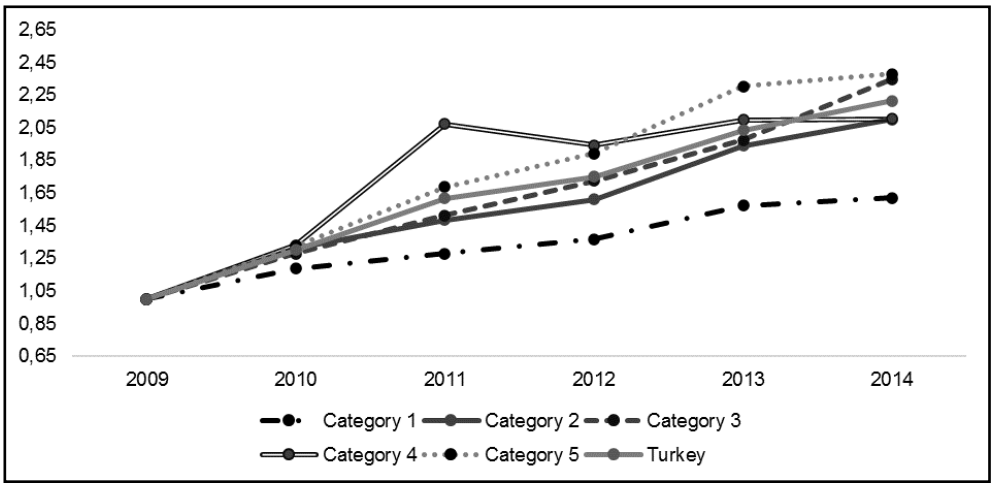

Fig. 3 - **Total Factor Productivity Change by PDI (Model 1)**

observed between the years 2009-2011. In this model, MTFPI also moves along with the technological change rather than the efficiency change. The directions are opposite with the Model 1 findings since the factors have changed sides.

Table 5 reveals the MTFPI over the years and it indicates a decrease in terms of total

Table 4

Input and Output Factors for Model 2

Inputs	Outputs
Participation Rate in Labor Force	Deposit (Turkish Lira)
Employment Rate	Deposit (Foreign Exchange)
Number of Workplace in Manufacturing Industry	Total Deposit
Net Profit in Manufacturing Industry	Tax Revenues
Personal Loans	Number Of Registered Investor to Stock Market
Sectoral Loans	Total Amount Of Account Balance
Non-Cash Sector Loans	
Energy Consumption	
Import	
Export	

productivity caused by technological change. By looking at the results in Table 2 and Table 5 together, it is possible to say that the direction of productivity depends on the treatment of loans. If loans are input factors, then there is a decline in the total productivity and vice versa.
Model 2 results can also be interpreted in terms of PDI. Fig. 5 presents the movement of MTFPI with respect to different categories. Every category experiences a decrease except for

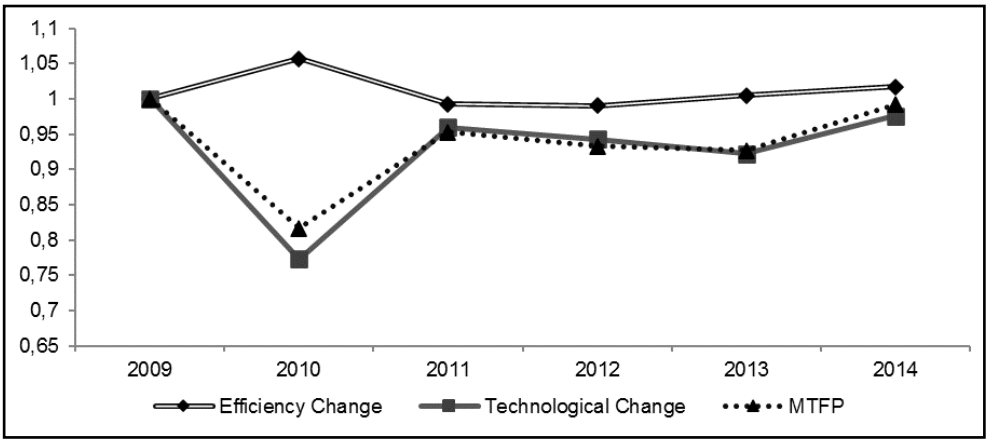

Fig. 4 - **Chart of MTFP by years (Model 2)**

category 4 between 2010 and 2011 (none of the MTFPI values are over 1 except for that one). Categories 1, 2, 3 and 5 follow mainly a stationary movement over the years. For category 4, there is a spike in 2011, followed by a relatively slower growth.

Table 5

Change in the Cumulative Efficiency by year (Model 2)

Years	Efficiency Change	Technological Change	MTFPI
2009	1	1	1
2010	1.057	0.773	0.817
2011	1.050	0.742	0.779
2012	1.039	0.700	0.726
2013	1.044	0.645	0.673
2014	1.062	0.630	0.668

Discussion

The findings presented in the previous section indicate that if the factors related to loans (personal loans, sectoral loans, and non-cash loans) are treated as outputs, growth in productivity is observed. Treating 'loans' as an output factor yields scores that are more closely

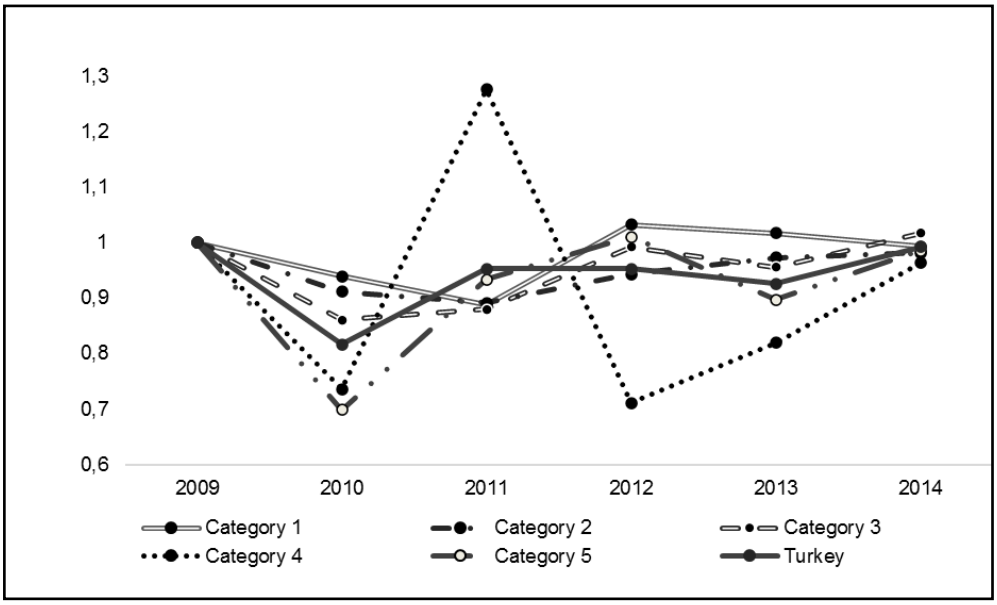

Fig. 5 - **Total Factor Productivity Change by PDI (Model 2)**

related to the GDP growth of Turkey during the given period. Fig. 6 visualizes the MTFPI scores of Model 1 at provincial level. It is noticeable that the eastern parts of the country experience a larger growth relative to the west. Some provinces attain a very high level of change (greater than 4), mostly located in the east. The east mostly consists of category 4 and 5 provinces; however, these provinces experience the largest growth according to Model 1.

Note that Model 1 considers 'loans' as outputs. We approach the factors associated with loans as a proxy of investment in this model. Of course, one should note that the analysis does not solely rely on the variables associated with loans. There are other financial outputs and also an input side of the story. We have variables on employment, the size of the manufacturing industry, etc. These will also differ between high-income and low-income provinces. Nevertheless, the Data Envelopment Analysis is about accounting for such trade-offs through the multi-dimensional relativity of output/input ratios. From that perspective, in the post-crisis period, there had been an expansion in the financial system at regional level, especially for less developed provinces according to Model 1. If loans indicate investment, then there had been a growth in regional development for the less developed regions after the 2008 crisis.

On the other hand, loans can be thought of as the proxy of indebtment as in Model 2. Fig. 7 visualizes the MTFPI scores of Model 2 at provincial level. It is observed that the majority of the provinces exhibit a decrease. When Fig. 6 and Fig. 7 are compared, it can be seen that only a few of the provinces could keep their productivity growth position. One province experiences a

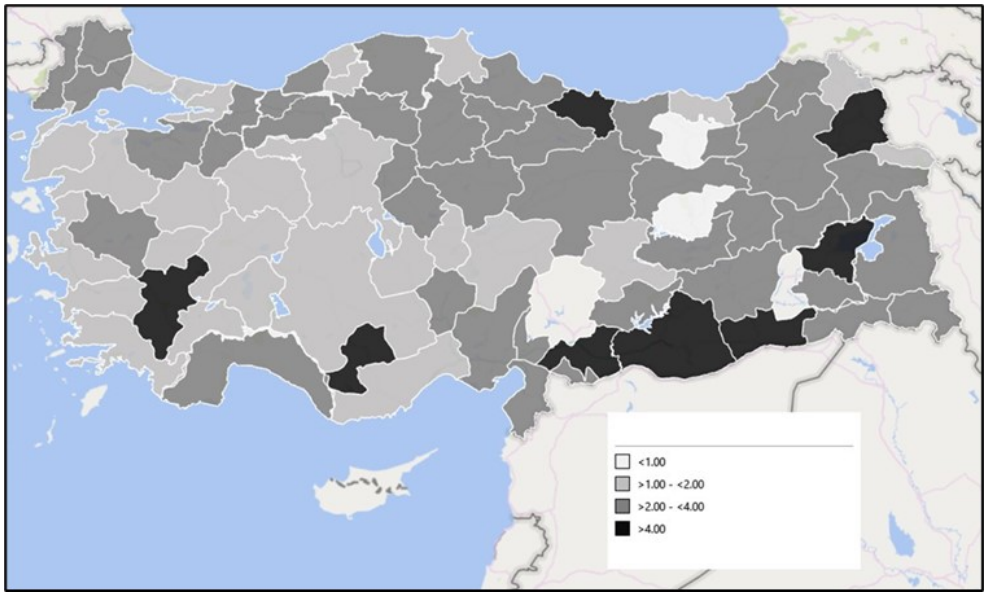

Fig. 6 - **Provinces by their MTFPI Scores (Model 1)**

high level of growth and only 10 provinces attain a score greater than 1. So, when the factors associated with loans are taken as inputs, the development levels of the provinces concerning banking and finance data reveal a decrease in all categories of provinces. This, of course, contradicts with the GDP growth during the given period. Note that loans include the cash and non-cash sectorial loans. If loans indicate debt, then there had been a decline in regional development for the entire country after the 2008 crisis. One advocating loans as a means of debt would think that the decrease in the development levels in the post-crisis period is based on recovering the effects of the recession during the crisis, which would be reasonable. The contradictions between the results of the two models reveal that the idea of growth is mainly affected by depending on the opinion towards the 'loans' provided by the banks.

It should also be noted that the technological change component is more effective in the change of MTFPI. The change mostly relies on the shifts on the frontier, in other words, the technological change component. Rather than individual changes in the scores (corresponding to the efficiency change component) of individual units (provinces in our case), the growth, or decline mostly, is mainly based on the shift of the frontier as a whole. In other words, from whichever perspective we approach the problem, the effects of the crisis are visible throughout the entire sample rather than the small changes at unit level.

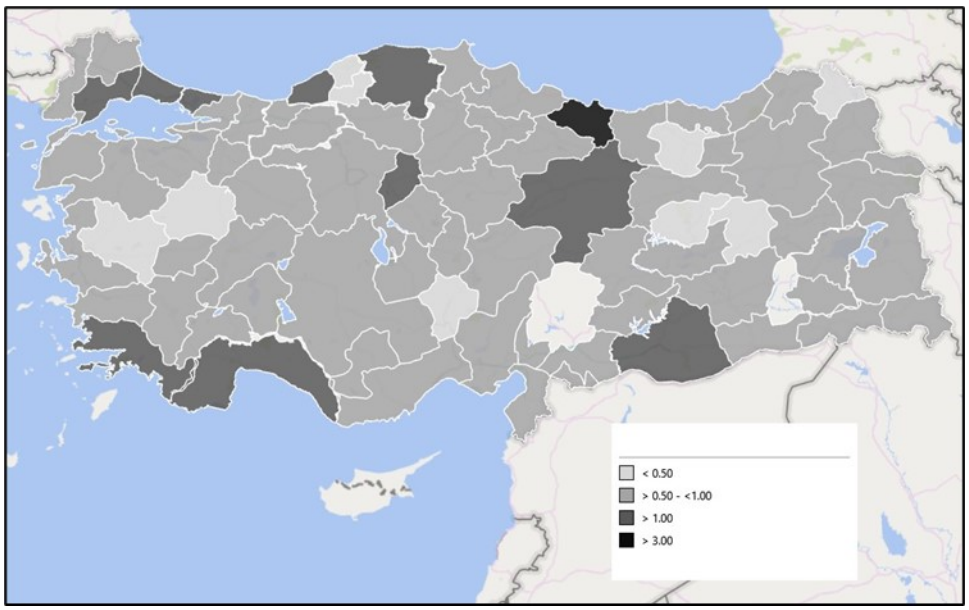

Fig. 7 **- Provinces by their MTFPI Scores (Model 2)**

Conclusions

In this paper, we aim to measure the provincial level financial performance of Turkish provinces using banking and finance data along with other economic indicators. For this purpose, we develop two Data Envelopment Analysis (DEA) models, mainly differing from each other in terms of handling the factors associated with 'loans', which turns out to affect the results when the direction of those variables is changed. The methodology is based on relativity and multi-dimensionality so that a broad perspective on regional development is aimed to be presented. As well as being a non-parametric efficiency evaluation method, DEA can also serve as an effective tool for a relative assessment in measuring regional development levels. Besides, we use a multi-period structure and the Malmquist Total Factor Productivity Index (MTFPI) method is employed to measure the change in 5 years after the 2008 crisis (between 2009 and 2014). The index is composed of two main components, namely as efficiency change and as technological change. The former represents the changes in the efficiency of individual units, whereas the latter is based on the shift in the production technology as a whole. The results are interpreted with respect to cumulative changes and to provincial development index categories. The results presented at cumulative and provincial level categories may reveal potential improvement areas and the provinces that require attention in managing regional development.

We evaluate the provincial development levels in Turkey and its change over the years, leaning

on the idea that banking data can provide an additional perspective to the assessment of regional development. Considering the banks' key role in the financial system, the evaluations fed by the banking perspective along with the macroeconomic indicators can contribute to the way we approach regional development. The use of DEA in a mix of economic and financial/ banking indicators conveys a new perspective to the assessment. Of course, banking data requires careful handling since different perspectives may lead to different directions as exposed by the findings of this research.

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Appendix
Table A1

Model 1: Ranking Cumulative Efficiency Change of Provinces

Rank	Provinces	Efficiency Change	Rank	Provinces	Technological Change	Rank	Provinces	MTFPI
1	Şanlıurfa	1.815	1	Ordu	5.898	1	Şanlıurfa	8.292
2	Muş	1.411	2	Bitlis	4.783	2	Ordu	7.558
3	Ordu	1.282	3	Kars	4.713	3	Bitlis	5.631
4	Ağrı	1.276	4	Şanlıurfa	4.573	4	Kars	4.713
5	Bursa	1.270	5	Yozgat	4.035	5	Mardin	4.478
6	Denizli	1.235	6	Kilis	3.809	6	Karaman	4.433
7	Erzurum	1.216	7	K.maraş	3.772	7	Gaziantep	4.369
8	Karaman	1.211	8	Mardin	3.763	8	K.Maraş	4.351
9	Tekirdağ	1.205	9	Gaziantep	3.679	9	Denizli	4.318
10	Mardin	1.189	10	Karaman	3.660	10	Hatay	3.848
11	Gaziantep	1.189	11	Hatay	3.654	11	Muş	3.639
12	Bitlis	1.177	12	Denizli	3.499	12	Yozgat	3.458
13	K. Maraş	1.154	13	Erzincan	3.499	13	Elazığ	3.370
14	Düzce	1.133	14	Tokat	3.492	14	Siirt	3.284
15	İzmir	1.129	15	Osmaniye	3.408	15	Sivas	3.237
16	Sakarya	1.098	16	Elazığ	3.370	16	Kilis	3.164
17	Hakkari	1.089	17	Siirt	3.285	17	Bilecik	3.039
18	Bilecik	1.067	18	Amasya	3.093	18	Erzincan	3.019
19	Samsun	1.061	19	Sivas	3.085	19	Kırıkkale	2.910
20	Zonguldak	1.059	20	Giresun	3.028	20	Osmaniye	2.890
21	Hatay	1.053	21	Çankırı	2.965	21	Düzce	2.835
22	Sivas	1.048	22	Kırıkkale	2.910	22	Amasya	2.762
23	Balıkesir	1.045	23	Bilecik	2.849	23	Erzurum	2.718
24	Manisa	1.010	24	Çorum	2.785	24	Samsun	2.689
25	Aksaray	1.000	25	Kastamonu	2.768	25	Tokat	2.673
26	Ankara	1.000	26	Van	2.741	26	Kastamonu	2.643
27	Antalya	1.000	27	Adıyaman	2.711	27	Tekirdağ	2.632
28	Ardahan	1.000	28	Muş	2.577	28	Şırnak	2.479
29	Artvin	1.000	29	Şırnak	2.574	29	Bingöl	2.476
30	Batman	1.000	30	Bingöl	2.544	30	Bursa	2.465
31	Bayburt	1.000	31	Samsun	2.538	31	Sakarya	2.463
32	Edirne	1.000	32	Diyarbakır	2.531	32	Batman	2.429
33	Elazığ	1.000	33	Düzce	2.501	33	Edirne	2.419
34	Eskişehir	1.000	34	Adana	2.445	34	Zonguldak	2.413
35	Iğdır	1.000	35	Malatya	2.442	35	Adana	2.410
36	İstanbul	1.000	36	Batman	2.429	36	Çankırı	2.400
37	Karabük	1.000	37	Edirne	2.419	37	Diyarbakır	2.391
38	Kars	1.000	38	Niğde	2.391	38	Hakkari	2.383
39	Kırıkkale	1.000	39	Bolu	2.367	39	Giresun	2.361
40	Kırklareli	1.000	40	Rize	2.349	40	Rize	2.349

Appendix
Table A1

Model 1: Ranking Cumulative Efficiency Change of Provinces

Rank	Provinces	Efficiency Change	Rank	Provinces	Technological Change	Rank	Provinces	MTFPI
41	Kırşehir	1.000	41	Bayburt	2.318	41	Bayburt	2.318
42	Kocaeli	1.000	42	Zonguldak	2.279	42	Adıyaman	2.289
43	Mersin	1.000	43	Kırklareli	2.250	43	Manisa	2.260
44	Muğla	1.000	44	Sakarya	2.242	44	Kırklareli	2.250
45	Nevşehir	1.000	45	Erzurum	2.236	45	Ağrı	2.233
46	Rize	1.000	46	Manisa	2.232	46	Niğde	2.195
47	Trabzon	1.000	47	Kayseri	2.214	47	Çorum	2.185
48	Tunceli	1.000	48	Hakkari	2.185	48	Antalya	2.131
49	Yalova	1.000	49	Tekirdağ	2.184	49	Kırşehir	2.097
50	Gümüşhane	1.000	50	Antalya	2.131	50	Bolu	2.058
51	Siirt	0.999	51	Sinop	2.119	51	Artvin	2.027
52	Isparta	0.997	52	Kırşehir	2.097	52	Van	2.002
53	Burdur	0.996	53	Bartın	2.066	53	Nevşehir	1.994
54	Adana	0.986	54	Afyonkarahisar	2.034	54	Trabzon	1.993
55	Uşak	0.982	55	Artvin	2.027	55	Kayseri	1.949
56	Bingöl	0.972	56	Nevşehir	1.994	56	Malatya	1.911
57	Şırnak	0.962	57	Trabzon	1.993	57	Burdur	1.897
58	Çanakkale	0.958	58	Bursa	1.941	58	Iğdır	1.884
59	Kastamonu	0.956	59	Burdur	1.902	59	Yalova	1.862
60	Diyarbakır	0.946	60	Iğdır	1.884	60	Bartın	1.828
61	Aydın	0.940	61	Yalova	1.862	61	Karabük	1.800
62	Niğde	0.917	62	Kütahya	1.814	62	Sinop	1.793
63	Amasya	0.893	63	Karabük	1.800	63	Eskişehir	1.734
64	Konya	0.891	64	Ağrı	1.748	64	Çanakkale	1.586
65	Bartın	0.886	65	Eskişehir	1.734	65	Kütahya	1.575
66	Kayseri	0.880	66	Çanakkale	1.653	66	Aksaray	1.558
67	Bolu	0.869	67	Aksaray	1.558	67	Ardahan	1.550
68	Kütahya	0.868	68	Ardahan	1.550	68	İstanbul	1.507
69	Erzincan	0.861	69	Aydın	1.537	69	Uşak	1.492
70	Yozgat	0.857	70	Konya	1.525	70	Muğla	1.467
71	Osmaniye	0.848	71	Uşak	1.519	71	Kocaeli	1.466
72	Sinop	0.847	72	İstanbul	1.507	72	Afyonkarahisar	1.454
73	Adıyaman	0.844	73	Muğla	1.467	73	Aydın	1.447
74	Kilis	0.830	74	Kocaeli	1.466	74	Ankara	1.366
75	Çankırı	0.810	75	Ankara	1.366	75	Konya	1.355
76	Çorum	0.784	76	Isparta	1.237	76	Isparta	1.235
77	Malatya	0.783	77	Mersin	1.230	77	Mersin	1.230
78	Giresun	0.779	78	Balıkesir	1.121	78	Balıkesir	1.172
79	Tokat	0.766	79	İzmir	1.012	79	İzmir	1.144
80	Van	0.730	80	Gümüşhane	0.297	80	Gümüşhane	0.297
81	Afyonkarahisar	0.716	81	Tunceli	0.109	81	Tunceli	0.109

Table A2

Model 2: Ranking Cumulative Efficiency Change of Provinces

Ranking	Provinces	Efficiency Change	Ranking	Provinces	Technological Change	Ranking	Provinces	MTFPI
1	Ordu	1.835	1	Ordu	1.961	1	Ordu	3.597
2	Şanlıurfa	1.633	2	Kırıkkale	1.424	2	Kırıkkale	1.424
3	Kastamonu	1.484	3	Antalya	1.219	3	Antalya	1.312
4	Tekirdağ	1.417	4	Sivas	1.142	4	Sivas	1.238
5	Sakarya	1.361	5	Kırklareli	1.055	5	Şanlıurfa	1.076
6	Bitlis	1.343	6	Kayseri	1.045	6	Kastamonu	1.067
7	Kars	1.283	7	İstanbul	1.040	7	Zonguldak	1.048
8	Kütahya	1.251	8	Muğla	1.034	8	İstanbul	1.040
9	Yozgat	1.220	9	Kırşehir	0.993	9	Muğla	1.034
10	Samsun	1.217	10	Zonguldak	0.991	10	Tekirdağ	1.032
11	Bilecik	1.192	11	Ankara	0.948	11	Kırşehir	0.993
12	Çankırı	1.183	12	Yalova	0.940	12	Kayseri	0.977
13	Tokat	1.178	13	Nevşehir	0.933	13	Kırklareli	0.963
14	Adıyaman	1.167	14	Diyarbakır	0.933	14	Ankara	0.948
15	Burdur	1.129	15	Mersin	0.907	15	Yalova	0.940
16	Elazığ	1.126	16	Trabzon	0.858	16	Yozgat	0.935
17	Karaman	1.124	17	Eskişehir	0.857	17	Nevşehir	0.933
18	Bayburt	1.114	18	Rize	0.851	18	Karaman	0.923
19	Manisa	1.113	19	Karaman	0.820	19	Trabzon	0.917
20	Erzincan	1.102	20	Hatay	0.813	20	Mersin	0.907
21	Balıkesir	1.097	21	Edirne	0.808	21	Elazığ	0.889
22	Sivas	1.085	22	Iğdır	0.808	22	Rize	0.851
23	Erzurum	1.077	23	İzmir	0.799	23	Edirne	0.847
24	Antalya	1.074	24	Elazığ	0.789	24	Hatay	0.846
25	Trabzon	1.069	25	Aksaray	0.780	25	Iğdır	0.837
26	Amasya	1.067	26	Erzurum	0.774	26	Diyarbakır	0.836
27	Düzce	1.065	27	Yozgat	0.766	27	Erzurum	0.834
28	Osmaniye	1.064	28	Giresun	0.736	28	Eskişehir	0.818
29	Zonguldak	1.056	29	Bayburt	0.733	29	Bayburt	0.816
30	Edirne	1.048	30	Tekirdağ	0.727	30	İzmir	0.799
31	Hatay	1.041	31	Kastamonu	0.718	31	Bitlis	0.790
32	Çorum	1.037	32	Artvin	0.716	32	Erzincan	0.787
33	Iğdır	1.036	33	Erzincan	0.715	33	Tokat	0.785
34	Aydın	1.035	34	Çorum	0.715	34	Aksaray	0.780
35	Batman	1.035	35	Balıkesir	0.709	35	Balıkesir	0.779
36	Ağrı	1.035	36	Amasya	0.702	36	Amasya	0.749
37	Niğde	1.033	37	Siirt	0.700	37	Kars	0.746
38	Afyon	1.022	38	Gaziantep	0.699	38	Çorum	0.741
39	Sinop	1.014	39	K.Maraş	0.697	39	Samsun	0.740
40	Bartın	1.005	40	Kocaeli	0.689	40	Giresun	0.720

Table A2

Model 2: Ranking Cumulative Efficiency Change of Provinces

Ranking	Provinces	Efficiency Change	Ranking	Provinces	Technological Change	Ranking	Provinces	MTFPI
41	Bolu	1.002	41	Çanakkale	0.672	41	Artvin	0.716
42	Van	1.001	42	Tokat	0.667	42	Siirt	0.700
43	Muş	1.001	43	Şanlıurfa	0.659	43	Kocaeli	0.689
44	Yalova	1.001	44	Adana	0.645	44	K.Maraş	0.678
45	Aksaray	1.000	45	Uşak	0.636	45	Çanakkale	0.672
46	Ankara	1.000	46	Aydın	0.623	46	Gaziantep	0.658
47	Ardahan	1.000	47	Denizli	0.623	47	Aydın	0.645
48	Artvin	1.000	48	Bursa	0.616	48	Adana	0.638
49	Bingöl	1.000	49	Samsun	0.608	49	Uşak	0.636
50	Çanakkale	1.000	50	Mardin	0.603	50	Burdur	0.621
51	Gümüşhane	1.000	51	Hakkari	0.600	51	Sakarya	0.618
52	Hakkari	1.000	52	Bitlis	0.590	52	Bursa	0.616
53	Isparta	1.000	53	Kars	0.581	53	Hakkari	0.600
54	İstanbul	1.000	54	Van	0.574	54	Düzce	0.593
55	İzmir	1.000	55	Şırnak	0.569	55	Van	0.574
56	Karabük	1.000	56	Muş	0.562	56	Batman	0.574
57	Kırıkkale	1.000	57	Düzce	0.556	57	Ağrı	0.572
58	Kırşehir	1.000	58	Batman	0.556	58	Adıyaman	0.571
59	Kocaeli	1.000	59	Ağrı	0.553	59	Şırnak	0.569
60	Mersin	1.000	60	Bolu	0.551	60	Muş	0.562
61	Muğla	1.000	61	Burdur	0.550	61	Afyon	0.557
62	Nevşehir	1.000	62	Malatya	0.549	62	Bolu	0.552
63	Rize	1.000	63	Afyon	0.546	63	Malatya	0.548
64	Siirt	1.000	64	Isparta	0.542	64	Denizli	0.547
65	Şırnak	1.000	65	Konya	0.531	65	Isparta	0.542
66	Tunceli	1.000	66	Kilis	0.506	66	Çankırı	0.541
67	Uşak	1.000	67	Sinop	0.500	67	Mardin	0.526
68	Malatya	0.999	68	Adıyaman	0.489	68	Bilecik	0.519
69	Bursa	0.998	69	Ardahan	0.489	69	Konya	0.509
70	Kilis	0.996	70	Osmaniye	0.477	70	Osmaniye	0.507
71	Adana	0.990	71	Bingöl	0.474	71	Sinop	0.507
72	Giresun	0.981	72	Çankırı	0.457	72	Kilis	0.504
73	K.Maraş	0.972	73	Sakarya	0.453	73	Ardahan	0.489
74	Konya	0.958	74	Bilecik	0.435	74	Kütahya	0.488
75	Eskişehir	0.955	75	Manisa	0.431	75	Manisa	0.479
76	Gaziantep	0.943	76	Niğde	0.413	76	Bingöl	0.474
77	Kayseri	0.935	77	Bartın	0.399	77	Niğde	0.427
78	Kırklareli	0.913	78	Kütahya	0.390	78	Bartın	0.401
79	Diyarbakır	0.897	79	Karabük	0.384	79	Karabük	0.384
80	Denizli	0.879	80	Gümüşhane	0.165	80	Gümüşhane	0.165
81	Mardin	0.871	81	Tunceli	0.004	81	Tunceli	0.004

Table A3

Province Classes in PDI

Categories	Provinces
Category 1	Ankara, Antalya, Bursa, İstanbul, İzmir, Kocaeli
Category 2	Adana, Aydın, Balıkesir, Çanakkale, Denizli, Eskişehir, Gaziantep, Hatay, Kayseri, Konya, Manisa, Mersin, Muğla, Sakarya, Samsun, Tekirdağ, Trabzon
Category 3	Afyonkarahisar, Amasya, Bartın, Bilecik, Bolu, Burdur, Çorum, Diyarbakır, Düzce, Edirne, Elazığ, Erzurum, Isparta, K. Maraş, Karabük, Karaman, Kırıkkale, Kırklareli, Kütahya, Malatya, Nevşehir, Rize, Sivas, Şanlıurfa, Uşak, Yalova, Zonguldak
Category 4	Aksaray, Artvin, Çankırı, Erzincan, Giresun, Kastamonu, Kırşehir, Mardin, Niğde, Ordu, Osmaniye, Sinop, Tokat, Tunceli
Category 5	Adıyaman, Ağrı, Ardahan, Batman, Bayburt, Bingöl, Bitlis, Gümüşhane, Hakkari, Iğdır, Kars, Kilis, Muş, Siirt, Şırnak, Van, Yozgat

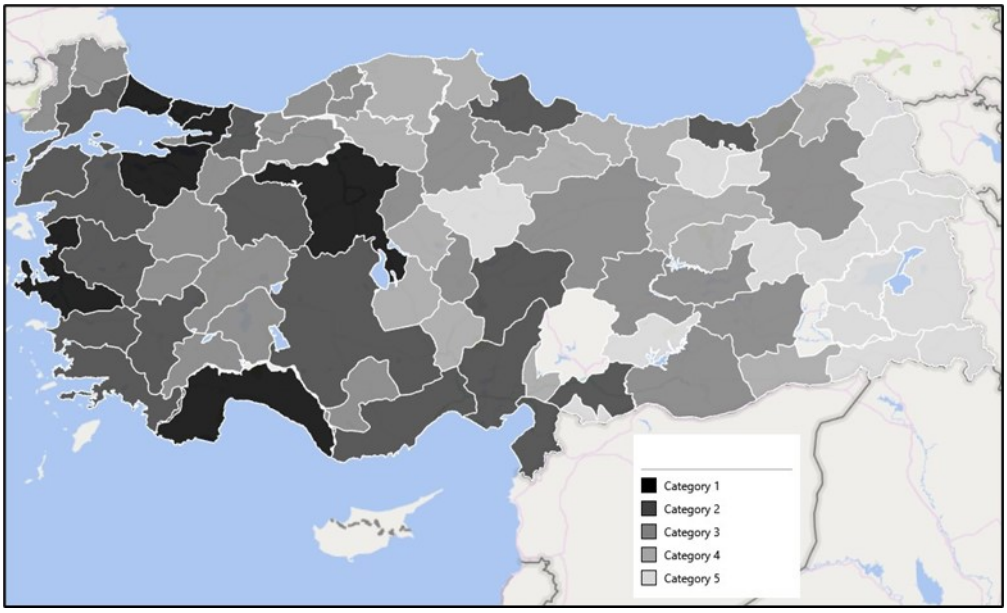

Fig. A1 - **Classified Provinces of Turkey**