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Measuring the Technical Efficiency of Telecommunication Sector within Global Crisis:

Comparison of G8 Countries and Turkey

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Abstract

In recent years, there has been a fierce competition in the telecommunication sector. Technologic competition has made the competition in the sector a kind of strategic war. The sector of which role increased in terms of economic developments has entered a reconstruction process at an equal rate in all countries. In fact, countries which apprehend the future of the sector will also determine the future of economy. In this respect the aim of this study is to make performance benchmarking by using Data Envelopment Analysis and Malmquist Total Factor Productivity Index on telecommunication sector which is thought as one of the most important signs of national economies in the global economic crisis environment. This benchmarking, which includes the period of global crisis between the years of 2007-2010, targets to measure to what extent countries have been affected from the global crisis environment by means of performance evaluation among the strongest telecom managements of countries such as Turkey and Group of Eight (G8) countries? In the study, annual activity reports of the managements and a variety of input and output variables acquired from various research institutions were used as a data set.

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1. Introduction

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In the telecommunication sector which is one of the most important indicators of economic development, many significant developments have been seen in recent years. Countries compete with each other by strengthening their telecommunication qualities. International performance evaluation has been significant for managements in the telecommunication sector that has been affecting the economy of countries directly because of the rapid increasing competition nowadays. Thanks to this national and international benchmarking, they'll be able to monitor their own situations in the sector and thus, they'll provide necessary betterments. The main purpose of this study is to compare the efficacy and total factor productivity of the leader company, Turk Telecom Inc. with G8 countries' leader companies in the telecommunication sector between the years of 2007-2010 when the global crisis affected all over the world.

The basic reason behind the use of G8 countries as a decision unit is that telecommunication is one of the most important signs of the development of countries and thus G8 countries are the most significant comparison standard for Turkey. In addition, the choice of managements operated in Turkey and G8 countries has been realized with findings as a result of literature studies and annual communication reports published by Organization for Economic Co-operation and Development (OECD). While the Data Envelopment Analysis, which is a kind of non-parametric mathematical programming based method, was used to measure efficiency, Malmquist Index was used to measure the total factor productivity (Valentin, Prieto, Santidran, 2003).

In the study, various financial and technological signs of the telecommunication managements in Turkey and G8 countries were used as data set. As a result of this measurement, different quantitative results were depicted for recoveries by analyzing performances of managements before and after the global crisis. Moreover, since a quantitative performance benchmarking was done related to Turk Telecom Inc. with developed markets, it would be a good evaluation for Turkey to see its situation in terms of telecommunication sector in an international arena.

2. Literature Review

The measurement of a company's performance is an operation series to determine whether companies have achieved their objectives or not, and it generates a phase of management process that consists of feedback motivation phases (Harrington, 1996). DEA which is the most frequently used method for production management and management science was developed by Charnes, Cooper and Rhados in 1978 (Korhonen, 2000). DEA gives the opportunity to measure without the need of any kind of analytic production function determined before as in parametric methods. But, all of the inputs have to be positive numbers and an empty input or output value should be defined (Kuosmanen, 2003). In the total factor productivity, total production functions or cost functions, limited functional forms and economic parameters affected by these limitations are calculated inferentially (Mao and Koo, 1996). Among researches done for the efficiency and total factor productivity measurements, performance benchmarking has been done for the related periods. Some of these studies are mentioned below. DEA application done by Tavers and Antunes in the telecommunication sector of OECD countries consists of the analysis of telecommunication services in OECD countries. In this study, a performance evaluation has been realized about the telecommunication services of OECD countries (Tavares and Antunes, 1998). The study titled as "Price summit regulations in Brazil telecommunication sector" done by Façanha and Resende has revealed the encouraging features of measurement diagram by creating a private reference for the practical applications of data envelopment analysis, economic infrastructure and quality performance (Façanha and Resende, 2004). In the study of "operational efficacy benchmarking among European strategic telecom managements" done by Pentzaropoulos and Giokas, data envelopment analysis was used for efficacy benchmarking among the main 19 Telecom operators in Europe (Pentzaropoulos and Giokas,

2002). The change application in production efficiency of local telecom companies realized in America by Uri was also measured with DEA to understand whether the encouraging regulations provide production efficacy or not (Uri, 2001). The production efficiency analysis of Greek telecommunication sector done by Pentzaropoulos and Giokas presented suggestions to prevent the existing inefficacy in the operational level but increase the production efficiency of the Greek Telecom Company's local system (Pentzaropoulos and Giokas, 2000). The efficacy measurement with the full-featured scoring method for the mobile telecom subscribers done by Shin and Shon, the full-featured customer evaluation method was suggested for the mobile phone subscribers in 2003 (Shin and Sohn, 2004). In the study about the comparative production efficacy of global telecom operators done by Tsai, Chen and Tzeng in 2005, it was proven that this analysis brings different efficiency standards together to determine the production efficiency of 39 leader telecom operators according to the order done by American Forbes 2000 journal (Tsai, Chen and Tzeng, 2005). Turk Telecommunication Inc. provincial telecommunication directorships' production efficiency measurement with DEA was done in 2006 and it was tried to determine the efficiency levels with the method of DEA by using November 2005 data of 82 provincial Turk Telecom directorships (Altun, 2006). In the study "First impressions for the comparison between Turkey and OECD and the variables of the information economy", it was aimed to discuss both the variables of information economy and position that compares Turkey with the other countries (Yeloğlu, 2009). The study called "The impact of information and communication technologies on export and an empirical analysis for Turkey" has been done to search about the effect of development or spread of information and communication technologies whether they play important role to increase Turkey's export or not (Karagöz, 2007).

3. World Electronic Communication Sector Overview

In recent years, there have been crucial developments in the electronic communication sector which is one of the most important impetuses for economic growth. Significant differences have been observed between countries and regions in the electronic communication sector in which parameters such as (GNP) Gross National Product, education, qualified manpower, foreign trade volume, incentives, and national strategies play effective role.

Those differences have been perceived in the electronic communication infrastructure and utilization of electronic communication services as well. At the end of the year 2009, while the world population went beyond the number of 6, 85 billions, the number of total fixed (1, 2 billions) and mobile subscriber (4, 63 billions) went beyond the number of 5, 8 billions. Thus, the number of mobile subscribers is almost four times more than fixed subscribers. Asian-Pacific Region had much more telephone subscribers (mobile and fixed) with 2, 7 billions fixed and mobile telephone subscribers by the end of 2009. According to the data of ITU (International Telecommunication Union), the number of mobile phone subscribers in the world was around 4, 62 billion by the end of 2009. The respective value approximately corresponded to 68% of the world's population. Thanks to developments made in terms of mobile services in Africa where the infrastructure of fixed telecommunication was limited, the access of individuals to the infrastructure of telecommunication increased. While there were only 12 millions fixed telephone subscribers in Africa, the number of mobile subscribers increased to 295 million by the end of 2009 (<http://www.itu.int/ITU-D/ict/eye>).

4. Telecommunication Sector in Turkey

The telecommunication market is the leading one which is the most important sector for EU. “Digital Agenda” which is one of 7 basic initiatives based on EU 2020 strategy is also related to telecommunication market directly. The return of electronic communication sector was 351 billion Euros in the USA in 2008 and this size nearly corresponded to the half of Information and Communication Technologies market. The 7th of the biggest 10 telecom operators in the world is the European origin companies. This critic sector which will shape the future of the world has been becoming crucial for Turkey. In Turkey, the national regulating authority in this field was called as the “Telecommunication Institution” in 2000 but it is now called as Information Technologies and Communication Institution which was changed by “Electronic Communication Law” in 2008. Telecommunication sector has gained acceleration and become stronger with important contributions of ITCI and thus the competition in the sector has increased day by day.

Turkey with its 10.436 USA dollars per capita GNP, 1, 1% economy growth, young population and modern network infrastructure in 2008 was a convenient market which let telecommunication sector develop. Moreover, our country was the 17th country of the world, 1st of the Middle East and 2nd of Europe in terms of its 71, 5 millions populations in 2008. The increase age average of the population of our country and the downward tendency of the number of the person per house has created important opportunities for the telecommunication sector. The privatization of Turkish telecommunication sector has both provided the understanding of better quality and putting package services on the market. Additionally, it let investment expenses increase (Şimşek, 2009). The main structure of the market has not changed within telecommunication services for ten years and Turk Telecom and three GSM managements (Turkcell, Vodafone and Avea) have maintained to be leading actors in the market.

- Size of the sector (2009): 24 Billions TL
- Institutions and Organizations: Policies of the sector are determined by the Ministry of Transport and regulations are implemented by ITCI. The ITCI has enough competence, but there are some problems related to the application of regulations.
- Fixed Telephone: 93% of the market is dominant in Turk Telecom. The total market share of next generation managements operating in this market is only 7%.
- Internet: TTNET owned by Turk Telecom has 81, 2%; next generation managements have 6, 15%; mobile managements have 8, 8 % and TURKSAT has 2, 5% of the market share.
- GSM: There are 3 companies operating in this field. Annual net sales returns of those companies are 12.9 billions TL.
- Cable TV: TURKSAT which is a state-owned company has the whole market share in this field (www.tk.gov.tr.)

5. Materials and Methodology

5.1. Research Design and Data Collection

In the application, some inputs and outputs determined as the most important varieties were used for the telecommunication sector as a result of the literature study. While the input varieties are “capital expenditure, debt, total access lines, employees”, the output varieties are “revenue, net income and mobile subscribers”. Data were collected from Organization for Economic Co-operation and Development (OECD) Communications Outlook Reports, Information Technologies and Communication Institution (ICT) Annual Reports and Telecommunication Industry Association (TIA) reports between the years of 2007 - 2010.

The aim of the study is to determine companies that had effective performance between G8 countries and Turkey telecommunication sector and thus to provide necessary recoveries for managements that

couldn't have effective performance. In this sense, data envelopment analysis was used to measure the efficiency of companies between years of 2007-2010. The measurement of the total factor productivity for the same period was done by means of Malmquist Index. In this study, it was benefited from Deap Solver 2.1 analysis program for the DEA and MI measurement.

In the study, the most effective managements found out by telecommunication researchers (OECD, ICT, TIA), which took part in the telecommunication sector in G8 countries, were used to choose decision units. Those managements and their countries are present in the table 3 below.

Table 1. Decision Units: G8 Countries and Turkey

Verizon (USA)	Telecom Italia(ITALY)
NTT (JAPAN)	BCE Inc.(CANADA)
Deutsche Telekom (GERMANY)	Mega Fon(RUSSIA)
Vodafone (UNITED KINGDOM)	Turk Telecom(TURKEY)
France Telecom(FRANCE)	

As for necessary input and output variables, they are present in the table 4 to benchmark the efficiency and total factor productivities of decision units.

Table 2. Input and Output Variables

Inputs	Outputs
I_1 . Capital Expenditure	O_1 . Revenue
I_2 . Total Debt	O_2 . Net income
I_3 . Total access lines	O_3 . Mobile Subscribers
I_4 . Employees units	

If chosen input is “m” and the number of output is “p”, a decision unit as $m + p + 1$ is a necessary constraint for the reliability of the research. As for the other constraint, the number of the decision unit must be double amount of the number of variable (Boussofiene, Dyson and Rhodes, 1991).

5.2. DEA Approach for Technical Efficiency

In the application, the data envelopment analysis was used for the measurement of companies' relative activities within G8 and Turkey telecommunication sectors. The data envelopment analysis which is a kind of linear programming technique is one of the most frequently used non-parametric methods. It compares companies which have a homogenous structure and then evaluate other companies by regarding the company which has the best observation as an efficiency frontier. While determining the efficiency frontier, Data Envelopment Analysis is based on actual observation not assumed one. That is why; random bug parameters were not used. Additionally, it can be necessary to extract data which has observations on extremum points (Linna, Nordblad and Koivu, 2003).

The efficiency of an “economic decision making unit” of which efficiency is required to be calculated;

$$\frac{v_1 y_{1j} + v_2 y_{2j} + \dots}{w_1 x_{1j} + w_2 x_{2j} + \dots} \tag{1}$$

It can be shown with a mathematical equality. Here;

- v_1 = the weight of 1st output
- y_{1j} = the 1st output obtained from the unit “j”
- w_1 = the weight of the 1st input
- x_{1j} = the 1st input used by the unit “j”

6. Methods in the Data Envelopment Analysis

Basically, three methods are used in the Data Envelopment Analysis. These methods are;

- CCR (Charnes-Cooper-Rhodes) Method
- BCC (Banker-Chaenes-Cooper) Method
- SBM (Slacks-Based Measure of efficiency) Method

Rational programming and linear programming transformation can be used in all methods on condition that input and output orientations are considered (Seiford, L.M., 1996).

6.1. CCR Method

CCR method is based on the assumption of fixed return to scale. If the efficient of the unit “j” is “ h_j ” the aim must be the maximization of this value. In this respect, objective function can be expressed as in the 2nd formula. (Grifell-Tatje and Lowell, 1995).

$$Enbh_j = \frac{\sum_{r=1}^n u_r y_r}{\sum_{i=1}^m v_i x_i} \quad (2)$$

6.2. BCC Method

It is a kind of model obtained from CCR model’s assumptions with some modifications. This model is based on variable return assumption to basic scale. It was developed by Banker-Charnes-Cooper. Return to scale can also be determined for decision units by using BCC model. BCC range is always under CCR range. For that reason, CCR efficiency score is immeasurably smaller than BCC efficiency score or equal.

6.3. SBM Method

CCR and BCC models are evaluated as input and output oriented. If a model is evaluated with these two types of orientations, it is then an additive model. As result of this model, an efficient score is not acquired. The efficiency of decision units is determined by analyzing slack variable values. If the value of two slack variables is 0, that decision unit will be efficient according to this model.

6.4. Malmquist Approach for Total Factor Productivity Index

As for the total factor productivity measurement, it was benefited from Malmquist TFV index in this study. Malmquist TFV index was used to be able to analyze the change nettably in activities of companies by years. The value of MI was commented as a change in the total factor productivity and it measured the

change in the productivity by means of two components which of them were change in the technical efficiency and change in the technology. Multiplication of those two components gives us MI (Grifell-Tatje and Lowell, 1995). The technical efficiency consists of pure technical efficiency and scale efficiency and the multiplication of those two indexes give us the technical efficiency. As for pure technical efficiency, managerial efficiency, scale efficiency; they question whether companies themselves work in the best scale or not. By means of the change in technology, the course of the change in the quantity of output generated from the same input is searched out (Worthington, 2001).

7. Results

In the study, DEA which is designed for the input was evaluated with 4 input and 3 output variables. Two models were computed under the competing assumptions of constant returns to scale (CRS) and variable returns to scale (VRS). Analysis results based on assumptions of the fixed return to scale and variable return are seen in the table 3 and table 4.

Table 3. Technical Efficiency Results 2007-2010 CRS

Name Of Cooperative	2007	2008	2009	2010	Average
Verizon	0,8570	1,0000	0,7050	1,0000	0,8905
NTT	1,0000	0,8196	0,8867	1,0000	0,9266
Deutsche Telekom	0,8459	1,0000	0,8333	1,0000	0,9198
Vodafone	1,0000	0,8264	0,9130	0,8264	0,8915
France Telekom	0,7927	0,9226	0,7384	0,9788	0,8581
Telecom Italia	0,9740	0,7724	0,9192	1,0000	0,9164
BCE Inc.	0,7796	0,9444	1,0000	1,0000	0,9310
MegaFon	0,9601	0,8264	1,0000	0,8333	0,9050
Turk Telecom	0,8257	0,8915	0,8485	1,0000	0,8914

When analyzing fixed efficiency to scale values in the table 3, it is seen that NTT and Vodafone managements were 100% efficient, and Telecom Italia and MegaFon managements had high scores such as 0, 97 and 0, 96 in 2007. As for the end of the period of 2007 and 2008 when global economic crisis was effective, we see that Verizon and Deutsche Telekom were 100% effective and other managements were not affected on a large scale in 2008. The most effective period of Turk Telecom managements was 2010 when compared to other years. The whole efficiency was not seen in other years except for this period. BCE Inc. and MegaFon were 100 % effective in 2009. It is clearly understood that 6 of 9 managements analyzed in the study were 100% effective in 2010 when recent effects of global economic crisis were seen.

Table 4. Technical Efficiency Results 2007-2010 VRS

Name Of Cooperative	2007	2008	2009	2010	Average
Verizon	0,9394	1,0000	0,8472	1,0000	0,9467
NTT	1,0000	0,9009	0,9589	1,0000	0,9650
Deutsche Telekom	0,9052	1,0000	0,9091	1,0000	0,9536
Vodafone	1,0000	0,9091	0,9524	0,9091	0,9427
France Telekom	0,9394	0,9508	0,8521	1,0000	0,9356
Telecom Italia	1,0000	0,8472	0,9589	1,0000	0,9515
BCE Inc.	0,9052	0,9589	1,0000	1,0000	0,9660
MegaFon	1,0000	0,9091	1,0000	0,9091	0,9546
Turk Telecom	0,9154	0,9508	0,9091	1,0000	0,9438

When examining the fixed efficiency values to scale in the crisis and resolution of crisis period, it is seen that the efficiency of Turk Telecom did not vary even though there was 100% efficiency after crisis by 2010. According to results of variable efficiency to scale in the table 4 , NTT, Vodafone, Telecom Italia and MegaFon managements used their resources quiet efficient and they realized their variable returns 100% in 2007. But there was a decrease owing to insufficient resources and global economic crisis which caused Verizon and Deutsche Telekom to be efficient after the following year. In 2009, BCE Inc. and MegaFon were % 100 efficient. As for the year 2010 when the global economic crisis lost its effect on all sectors on a large scale, variable efficiency scores to scale were 100% except for two companies. When compared to G8 countries managements, Turk Telecom management was 100% efficient only in 2010. Apart from that year, this management generally showed less success in other years. When analyzing average efficiency values between years of 2007-2010, it is observed that the first management which had the most efficient average was BCE Inc. and the second one was NTT.

According to fixed and variable efficiency scores to scale as a result of the evaluation of DEA, common failures were realized in performances of managements because of the global economic crisis in 2007 and 2008. When the global economic crisis started to be resolve in 2010, a common betterment was seen in performances of managements. In the light of this information, the performance of Turk Telecom and G8 countries managements were not affected on a large scale, what's more their performances increased in that period. It can be said that Turk Telecom management displayed lower performance than G8 countries managements according to general average of both fixed return and variable return to scale evaluations.

Table 5. Average Malmquist Total Factor Productivity Change 2007-2010 Periods

Name Of Cooperative	Technical Efficiency Change	Technical Change	Pure Efficiency Change	Scale Efficiency Change	Total Factor Productivity Change
Verizon	1.039	1.092	1.000	1.039	1.135
NTT	1.025	0.985	1.009	1.016	1.009
Deutsche Telekom	1.045	0.992	1.037	1.008	1.037
Vodafone	0.982	0.900	0.982	1.000	0.884
France Telekom	1.000	1.009	1.000	1.000	1.009
Telecom Italia	1.025	0.953	0.999	1.026	0.977
BCE Inc.	1.028	0.968	1.014	1.014	0.996
MegaFon	1.028	0.960	1.006	1.022	0.987
Turk Telecom	0.994	0.990	1.003	0.991	0.983
Mean	1.027	1.051	1.010	1.016	1.048

The change in the total factor productivity seen in the table 5 was given as a period average for the years of 2007- 2010. According to table 5, the index of changes in the total factor productivity, technical efficiency and technology was seen as bigger than 1 which expressed the progress of the total factor productivity, technical and technological efficiency. The index which was smaller than 1, expressed the decline. Furthermore while the change index in the efficiency which was bigger than 1, expressed the effect of the best production frontier in the management, the change index of technology which was bigger than 1, expressed the rise and innovation production frontier.

The change in the efficiency consisted of pure efficiency and scale efficiency. Scale efficiency showed the success of the management whether it produced the best scale or not. When evaluating the table 5, it is realized that the change in both technical efficiency and technology was bigger than 1. That is; the managements that affect total factor productivity positively were Verizon and France Telekom. Turk Telekom could not show the same positive effect on technical efficiency and technology as in total factor productivity. While the best two performances among managements of which the change index of pure efficiency and scale efficiency were bigger than 1 were obtained by Deutsche Telecom and Verizon, Turk Telekom showed lower performance in terms of change in the efficiency. Moreover, as the change index in the efficiency which gave the production frontier, was bigger than 1 in the pure efficiency, the best production frontier was obtained subsequently. However as this index was smaller than 1 in the scale efficiency, the best production frontier could not be obtained in terms of efficiency to scale. When the change in the total factor productivity was taken into consideration, Verizon and France Telekom managements of which the change in the total factor productivity, technical efficiency and technology was bigger than 1, showed the best performance in technical efficiency and technology, and also made progress in the base period.

8. Findings and Conclusion

Telecommunication sector which is defined as one of the most important signs of an economically developed country will be a crucial economic scale in the global economic crisis environment. For that reason, development of countries in telecommunication sector will be a sign in terms of their economic welfare. In this study, the benchmarking of telecommunication sectors between Turkey and G8 countries was realized by means of efficiency and total factor productivity analysis. Those results will be an indicator for countries' economic stabilization in the crisis and resolution of the crisis environment. That is why; the period of 2007-2010, when the global economic crisis became effective, was evaluated in the study. Data Envelopment Analysis and Malmquist Total Factor Productivity Analysis were used to be able to do various quantitative evaluations.

In the study, it is perceived that companies were not highly affected by the global economic crisis environment; however they came out of the crisis environment stronger. When analyzing the average efficiencies of companies in the period of 2007-2010, the highest efficiency average was seen in BCE Inc. management with the ratio 0, 93 by years. Even though BCE Inc management operating in Canada telecommunication sector had the efficiency of 0, 77, it is seen that this management was less affected by the global crisis environment among years of 2008, 2009, 2010 and its fixed return efficiency increased by years. When searching into changes within total factor productivities and general averages in the period of 2007-2010, those results show that 9 managements operating in the telecommunication sector used their sources efficiently by years. The period of 2007-2010 which included the crisis and resolution of crisis period presented that telecommunication sector was somehow affected by the crisis environment "as it is an indicator of economic welfare for countries", but it was not affected on a large scale. The main

reason is that telecommunication sector has been the preeminent innovation means and compulsory investment for all sectors.

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