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Measuring the Efficiency of Turkish Natural Gas Distribution Companies Using Stochastic Frontier Analysis

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Türkiye Doğal Gaz Dağıtım Firmalarının Etkinliğinin Stokastik Sınır Analiziyle Ölçülmesi

Abstract

Natural gas should be distributed and consumed optimally in a given country since it is an important intermediate good for producers and a necessary final good for households with a low-income elasticity. Thus, this study aims to measure the efficiency of natural gas distribution companies responsible for delivering natural gas to economic units. The efficiency of 63 natural gas distribution companies operating in Turkey is estimated by the Stochastic Frontier Analysis method for 2013-2018. According to the findings, it is found that no firm operates within full efficiency. It is also concluded that while Bursa Natural Gas Distribution firm has the highest efficiency, Aksa Çanakkale Natural Gas Distribution firm has the lowest efficiency for the period studied. The findings show that inefficiency mainly stems from technical inefficiency rather than measurement errors and that natural gas distribution firms experience increasing returns to scale.

Keywords : Efficiency and Productivity, Natural Gas Market, Energy Economics, Stochastic Frontier Analysis, Natural Gas Distribution.

JEL Classification Codes : C33, D22, D24, D42, D61.

Öz

Gelir esnekliği düşük, firmalar için ara mal, hane halkları için nihai mal durumundaki doğal gazın ülke içinde dağıtımının ve kullanımının optimal gerçekleştirilmesi gerekmektedir. Bu gereklilikten hareketle, ilgili ekonomik birimlere doğal gazın ulaştırılmasında sorumluluğu üstlenen dağıtım firmalarının ne kadar etkin (ya da etkinsiz) çalıştığını ölçmek, bu çalışmanın amacını oluşturmaktadır. Bu amaç çerçevesinde, 2013-2018 yıllarını içeren dönemde Türkiye içinde faaliyet gösteren 63 doğal gaz dağıtım firmasının etkinliği Stokastik Sınır Analizi (SFA) yöntemiyle ölçülmektedir. Analiz sonuçlarına göre; hiçbir firmanın tam etkinlikte çalışamadığı, Bursa Şehir İçi Doğal Gaz Dağıtım firmasının en yüksek etkinliğe, Aksa Çanakkale Doğal Gaz Dağıtım firmasının ise en düşük etkinliğe sahip olduğu sonucuna ulaşılmaktadır. Bulgular; etkinsizliğin, ölçüm hatalarından çok, teknik etkinsizlikten kaynaklandığını ve firmaların ölçeğe göre artan getiride çalıştıklarını göstermektedir.

Anahtar Sözcükler : Etkinlik ve Verimlilik, Doğal Gaz Piyasası, Enerji Ekonomisi, Stokastik Sınır Analizi, Doğalgaz Dağıtım Firmaları.

1. Introduction

Energy is an indispensable input for almost all processes within the scope of everyday life of a community as it is widely used in industrial, transportation, housing and commercial sectors. The fossil fuels such as petroleum, natural gas and coal represent approximately 86% of the source's energy is produced around the world. Due to its extensive usage in electric production, natural gas has the second largest share in the world's primary energy consumption after petroleum. As of 2017, 33% and 24.1% of the world energy demand were met by petroleum and natural gas, respectively. The global aggregate gas reserves were increased by 0.2% from 193.1 trillion m^3 in 2016 to 193.5 trillion m^3 in 2017. 40.9% of the world's natural gas reserves are located in the Middle East, 30.6% in Eurasia, 10% in Asia Pacific, 7.1% in Africa, 5.6% in North America, 4.2% in Central and South America, and 1.5% in Europe. The natural gas reserve of the OECD countries in total were 17.8 trillion m^3 corresponding to around 9.2% of the global aggregate in 2017. Global natural gas production increased from 3.55 trillion m^3 in 2016 to 3.68 trillion m^3 in 2017, which represents a 4% increase within a year. The highest proportional increase in natural gas production was experienced in Eurasia with 6.2% and in the Middle East with 4.9% for the same period (EPDK, 2018).

The global reserve life is calculated as 52.6 years by dividing the reserve amount (193.5 trillion m^3) by the amount of natural gas production (3.68 trillion m^3) in 2017. An analysis of the regional distribution of reserves shows that the Middle East ranks first, Europe and Eurasia rank the second when considered together and the other Asia Pacific countries rank the third. In 2017, the global demand for natural gas reached 3.6 trillion m^3, an increase of 3% when compared to the demand faced in 2016.

Turkey is among the emerging economies with significant energy consumption. Turkey's primary energy demand in 2018 was met primarily by petroleum with 31%, by natural gas with 28% and by coal with 28%. In 2018 distribution of Turkey's primary energy demand by sector is as follows: 25% of consumption is used by industries, 24% of consumption is used in the residential areas and the service sector, 23% of consumption is used for electricity production, and 20% of consumption is used in the transportation sector. The ratio of primary energy demand to domestic production is around 25%, i.e. energy import dependency ratio stands at 75%. Foreign dependency ratio has increased significantly due to the large increase in natural gas consumption, especially since the early 1990s.

In 2008, Turkey produced as much as 1 billion cubic meters of natural gas, but in 2018, it fell to 428 million cubic meters. As of 2018, though, Turkey's natural gas consumption was 49,328 million cubic meters. Turkey's natural gas production only met 3.2% of its domestic consumption in 2004, while it could only meet 0.8% in 2018. Thus, importing natural gas from around the world for the remaining domestic demand, Turkey's natural gas import dependency ratio is around 99.1%. In 2018, the main sources of Turkey's natural gas imports were Russia, (46.9%), Iran (15.6%), Azerbaijan (14.9%) and Algeria (8.9%) (EPDK, 2018).

As of end of 2018, the total length of steel pipelines reached approximately 13,486 km. and the length of polyethylene pipelines reached approximately 90,140 km. The total number of households subscribing to natural gas distribution license holders increased by 8.71% and the number of free consumers increased by 8.94% compared to the previous year (2017). These continuing trends of growth in Turkey’s demand for natural gas does not seem to subdue in the upcoming years.

Imported natural gas might only have small impact with respect to the dynamics of the exporter’s own natural gas market; however, it has potential to jeopardize the importer country in its international relations, economic policies and/or political environment. Therefore, a resource-scarce country that is particularly vulnerable to volatilities in natural gas supply must be careful to distribute and use this resource as economically and effectively as possible. In case of a resource scarcity or an inefficient use of a scarce resource such as natural gas, a huge burden falls on economic units in both micro and macro levels of an economy (Hünerli & Aydın, 2019: 133). Thus, investigating the distribution of the imported natural gas in a country is the key to pinpoint the efficiency of the resource used. Efficiency depends on optimal and balanced returns to various investments of the companies responsible for distributing natural gas to the final consumers, and the companies’ successful transformation of their inputs into outputs. In this context, the aim of the study is to investigate how (in)effective distribution companies deliver this resource to the relevant economic units. To achieve this goal, the stochastic frontier analysis (SFA) was applied to data belonging to 63 natural gas distribution companies operating in Turkey for the 2013-2018 period, obtained through the Energy Market Regulatory Authority (EPDK).

In this context, the second section reviews the primary literature analyzing the efficiency of natural gas distribution companies. While the third section describes the data set used, the fourth section provides with an explanation of the methodology employed in the present study. Next, the fifth section presents the results obtained through empirical analyses. The final section concludes by presenting the main results and providing with important policy suggestions.

2. Literature Review

Although studies on the natural gas distribution sector are increasing, they are still relatively few when compared to the studies in the literature that have mainly focused on the measurement of the efficiency of the distribution companies in the electricity and the water distribution sectors. Researchers have started to focus more on the natural gas distribution sector, offering not only policy suggestions that could enable companies to improve their internal efficiency, but also providing guidance for reducing energy imports especially for the energy dependent countries (net energy importers). However, when the related literature is reviewed, it could be observed that the existing studies have been mostly restricted by the employment of Data Envelopment Analysis (DEA). Thus, employing a different method, namely the Stochastic Frontier Analysis, to calculate the efficiency of the natural gas distribution companies has the potential to both verify the robustness of the findings obtained in previous studies and to provide with considerably differentiated results. Notwithstanding, a brief review of the literature is presented below.

Kim et al. (1999) have researched Korean (The Republic) gas distribution industry by using a non-parametric method. They have concluded that nearly all (25 companies) DMUs (Decision-Making Units) work on increasing return to scale because of emerging market structures. Carrington et al. (2002) have used the same approach for investigating 24 Australian gas distribution companies. They have found that that results of benchmark technical efficiencies are 73% for constant rate of scale and 82% for variable rate of scale. Erbetta and Rappuoli (2003) have researched 46 Italian natural gas distribution companies' efficiency. They have used average costs and capital expenditures as inputs, and subscribers, shared volume and pipelines as outputs in their DEA. They have concluded that using categorical inputs increases the model's technical efficiency. In the same year, Hawdon has conducted an international research, which includes 33 countries. By using DEA, he has concluded that only eight countries were able to achieve technical efficiency in natural gas industries. Farsi, Filippini and Kuenzle (2004) have conducted research on cost efficiency of 26 Swiss natural gas distribution sector companies. They have used Stochastic Frontier Analysis Method. They have concluded that only 7% of the companies studied are fully efficient and reduction in costs depends primarily on increase in companies' output. A similar research has been conducted by Haney & Pollitt (2009) after six years. They have used Stochastic Frontier Analysis with firms operating in the gas and the electric sectors of 44 different countries. They have reached a conclusion that the benchmark technique was poorly applied in the natural gas sector but was highly employed in the electricity sector. Žorić et al. (2009) has researched the Slovenian natural gas distribution companies' efficiency comparing them with their peers operating in the UK and the Netherlands. By using DEA, benchmark method has been resulted with the efficiency of 42 Slovenian natural gas distribution companies being lower than those in the UK and the Netherlands. While distribution companies operating in the UK are working at a decreasing return to scale and the relatively more homogeneous companies in Slovenia are working at an increasing return to scale, those in the Netherlands are working close to an optimal scale. Ertürk and Türüt-Aşık (2011) have researched 38 Turkish natural gas distribution companies' efficiencies with DEA. They have showed that inefficient firms are immature and work on low-scale production.

Marques et al. (2013) have conducted research on 11 Portuguese natural gas distribution companies which is affected by governmental price regulations. They have concluded according to four different models that rates are differentiated and the companies mostly work with increasing returns to scale. This situation, thus, indicates that the sector has yet to reach the optimal point. Yanes et al. (2013) have researched 66 Australian companies' efficiency. By using Stochastic Frontier Analysis, they have reached the result that Australian gas distribution companies were required to benchmark with the American companies. As a result, the efficiency scores of the companies of the two countries display convergence. Storto (2014), using DEA, has conducted research on 32 Italian natural gas distributor companies. He concluded that Italian natural gas sector is broad, and it causes ineffective working. Also, the researcher found that firms under study face decreasing returns to scale. Oliveira, Correira and de Mello (2014) have conducted research about the oil and gas usage of six South American countries with DEA. By using DEA they have concluded that Ecuador, Venezuela, Colombia, Argentina, Brazil and Peru are vulnerable to oil and gas price volatilities. In accordance, they have suggested policies to decrease sectors' vulnerabilities and increase their durability's. Amirteimoori, Shahroodi and Mahmoodkiani (2015) using Vanilla DEA and Network DEA Method have estimated Iranian gas companies' cross efficiency scores for the period between 2002 and 2004. The researchers have decided that Network DEA is more reasonable for the country's industrial system. Martin-Gamboa, Iribarren and Dufour (2017) have researched Spanish natural gas plants' efficiency. They have used Life Cycle Assessment (LCA) and Dynamic Data Envelopment Analysis (DDEA) methods to evaluate plants' environmental performances for the period 2010-2015. They have reached that all plants show a relatively good environmental performance with overall eco-efficiency scores above 60%. Fillippini and Orea (2014) have researched Swiss natural gas distribution companies' effectiveness with Stochastic Frontier Analysis Method. They have concluded that measurement errors in prices and asymmetric prices affect the efficiency of the industry negatively. Research conducted by Hünerli and Aydın (2019) has involved 63 Turkish natural gas distribution companies. According to results obtained through DEA, they have reached that the ratio of effective firms to total firms was 10% based on CCR method (Charnes, Cooper & Rhodes, 1978), and 14% based on BCC method (Banker, Charnes & Cooper, 1984. It is concluded that inefficient firms are working with increasing returns to scale. Vikas and Bansal (2019) have researched efficiencies observed in the Indian oil and gas sectors to provide benchmark targets to the inefficient companies. They have concluded that only 13 companies out of 22 reached a full technical efficiency score. Ojaraida, Iledare and Idowu (2019) have examined Nigerian natural gas sector's productivity using DEA Method. The researchers have concluded that natural gas is not effectively utilized in the country and, thus, have affected economic growth negatively. The vulnerability indexes for the period under consideration were high, suggesting that Nigeria was not self-sufficient in natural gas. In addition, they have found a positive correlation between the natural gas consumption and the GDP of Nigeria.

3. Data and Decision Maker Units (Firms)

The inputs and outputs selected in the current study were determined according to similar studies found in the literature. In many studies, the number of workers, network length, price policies and transformer capacity were considered as inputs and variables such as number of customers, residential sales, non-residential sales, distribution area and maximum demand were taken as outputs. However, there are variables like the network length that could be selected as both input and output. In addition, some external variables are also proposed to test the externalities in small samples. The current study mainly follows Zorić et al. (2009) and Jamasb and Pollit (2003) for collecting inputs and outputs.

In the present research, the data were obtained from the Turkish Energy Market Regulatory Authority's (EPDK) sector reports published through 2013-2018. Specifically, Steel Pipeline Length, Polyethylene Pipeline Length, Investment Amount, Service Line Amount, Service Line Length, Number of Dwelling Subscribers, Number of Eligible Consumers, Consumption of Dwelling Subscribers, Consumption of Eligible Subscribers, Number of Staff, Sales Amount and Transportation Amount are extracted. However, number of variables were reduced due to the fact that some were not available in reports published for the initial years. Thus, the Amount of Service Lines and Length, and Investment and Transportation Amount have been excluded. The final variables to be used as inputs remained as Steel Pipeline Length, Polyethylene Pipeline Length and Number of Staff. On the output side, while Subscriber Consumptions and Sales Quantity were not included in the study due to lack of data, the number of Dwelling and Eligible Subscribers were included in the analysis after aggregation. As seen in Table 1, natural gas distribution efficiency calculated in the previous studies commonly used "number of employees, line length, carrying capacity, operating expenses, total expenses" as inputs, "number of subscribers, total shared volume, residential sales volume, service area, network length, maximum demand" as outputs (Zorić et al., 2009: 120).

Table: 1
Reference Variables

Inputs	Outputs	Environmental
-Number of Employees -Network Length (Km) -Transformer Capacity -Price Regulation and Policies (Opex, Totex, etc.)	-Number of Customers -Total Energy Delivered (Gwh, M^3) -Residential Sales (Gwh, M^3) -Non-Residential Sales (Gwh, M^3) -Service Area (Km^2) -Maximum (Peak) Demand (Mw, M^3/Day) -Network Length (Km)	-Network Length -Service Area -Maximum (Peak) Demand -Residential Sales -Non-Residential Sales -Share of Residential Sales -Customers Density (Per Km^2) -Network Mix -Customer Mix -Distribution Losses (Gwh, M^3) -GNP Per Capita

Source; Zorić et al., 2009: 120.

In the sample created from 63 natural gas distribution companies across seven geographical regions of Turkey, a total of 378 observations with three inputs and one output were utilized in the analysis for the 2013-2018 period. All data were used after a logarithmic transformation. The selected variables of the study and the descriptive statistics of the variables are presented in the Table 2.

Table: 2
Variables and Descriptive Statistics

Input/Output	Variables	Observation	Mean	Std. Dev.	Min	Max
Output	Number housing of subscribers (lny)	378	182,583.6	541,680.6	93	4,868,167
Input	Length of steel pipeline (meter) (k1)	378	11,512	20,517	4,660	116,207
	Length of polyethylene pipeline (meter) (k2)	378	170,891	290,427.5	8,598	204,228
	Number of staff members (l)	378	121,082	269.1448	15	2,139

The dataset covering 2013-2018 includes 1512 values belonging to four variables. The number of housing subscribers ranges from 93 to 4,868,000, with an average of 182,000. The average lengths of steel pipeline and polyethylene pipeline are approximately 11,000 km and 170,000 km., respectively.

4. Purpose and Methodology of the Study

The purpose of this study is to investigate how effective the Turkish natural gas distribution companies are in distribution. Theory wise, the main focus is on how scarce resources are distributed and used effectively. Thus, the paper's main aim is to examine the distribution of a scarce resource-natural gas in Turkey in order to determine how far away it is from an optimal distribution and, accordingly, how it should be distributed. Based on the notion of optimism in the Economics and Business literature, the paper also aims at suggesting ways to improve the efficiency of the natural gas distribution companies by revealing their existing conditions regarding efficiency. In this framework, three hypotheses are constructed:

Hypothesis 1: Increased demand increases the efficiency of natural gas distribution companies and the natural gas distribution market.

Hypothesis 2: Increases in returns to scale increases the efficiency of natural gas distribution companies.

Hypothesis 3: Increases in returns to scale in natural gas distribution companies increases competition in the sector through a cost advantage.

In order to achieve the aforementioned purposes and to investigate the related hypotheses, a parametric technique - Stochastic Frontier Analysis (SFA) - has been utilized. The results of the Skewness test (Appendix-1) is negative (-7.98), which indicates inefficiency. Results for "One-sided" refer to the standard stochastic frontier model. Appendix-2 provides with the probability of having skewness on the error term (kewness). As the probability is less than 5% (Pr: 0.0000), the hypothesis H0, which claims that there is no skew on the error term, is rejected. SFA has arisen as a result of a need to measure the distance between the most proper foreseeable application frontier and the performance actualized by a decision-maker unit.

As known, the biggest problem in deterministic models is the lack of inclusion of any error terms and other statistical noises (white noise). Thus, these models deem all the deviation from the frontier as a result of technical inefficiency. A clear solution to this problem is to add another variable to create some statistical noise. The frontier arising from this process is defined as the stochastic production frontier. Stochastic frontier model had been independently suggested by Aigner et al. (1977) and Meeusen and van der Broeck (1977). This model is defined as follows:

$$y_i = f(x_i;\beta)\exp(v_i - u_i) \quad i = 1,2,...,I \tag{1}$$

Here, v_i expresses the random error having zero average and u_i represents the random variables not being under control of the company (for instance, measurement errors in production, climate, industrial activity). The possible production y_i is limited by $f(x_i;\beta)\exp(v_i)$, which is the *stochastic frontier* amount. v_i ($i = 1,2,...,I$) random errors are distributed independently and identically, following a normal distribution ($N(0,\sigma_v^2)$), and they are independent from the u_i s that have a nonnegative kurtic normal distribution (such as semi-normal) or an exponential distribution. Meeusen and van der Broeck (1977) had their model constructed with only having exponential distribution ($r = 1$ and $\lambda > 0$) parameters like gamma distribution and had drawn attention to the fact that the model is not as restrictive as the model of Richmond (1974), which follows gamma distribution with a single parameter ($r = n$ and $\lambda = 1$). When Model (1) is transformed into natural logarithm, then:

$$\ln y_i = x_i\beta + v_i - u_i \tag{2}$$

Statistical noise can arise from measurement errors, and errors of estimation with respect to the selection of functional pattern as well as accidentally skipping of a variable from the vector x_i. Thus, as the output value of Model (2) is being limited from the top by $\exp(x_i\beta + u_i)$, which is a stochastic variable, Model 2 can be defined as a stochastic frontier production function.

As the error term v_i can be either negative or positive, stochastic frontier outputs change the deterministic part of the model, $\exp(x_i\beta)$. For this, by considering the company as limited, it was deemed that it obtains the output Y_i by the use of single input X_i. This state may be identified as follows when a Cobb-Douglas stochastic frontier model is used:

$$\ln y = \beta_\circ + \beta_1 \ln x_i + v_i - u_i \tag{3}$$

When an anti-logarithm transformation is applied, it turns into:

$$y_i = \exp(\beta_\circ + \beta_1 \ln x_i + v_i - u_i) \tag{4}$$

When the error terms of the model are explicitly written, then it becomes:

$$y_i = \exp(\beta_\circ + \beta_1 \ln x_i) + \underbrace{\exp(v_i)}_{noise} + \underbrace{\exp(u_i)}_{inefficiency} \tag{5}$$

Many stochastic frontier analyses are directed towards the forecast of estimation of the effects of inefficiency. The most general output-oriented measurement of technical efficiency has been defined as the ratio of the observed output to the relevant stochastic frontier output. This definition may be expressed with the following model:

$$TE_i = \left[y_i / \exp(x_i \beta) + v_i \right] = \left[\exp(x_i \beta + v_i - u_i) \right] / \left[\exp(x_i \beta + v_i) \right] = \exp(-u_i) \qquad (6)$$

This measurement of technical efficiency gets values between 0 and 1. This measures the output of i^{th} company as per the production ability output of a fully effective company by the use of the same input vector. It is clear that the first step in TE_i, the technical efficiency forecast, is the estimation of parameters of the stochastic production frontier model.

Various statistical operations applied in different estimation methods and hypothesis testing can also be generalized for the stochastic frontier. However, the estimation here displays more complexity as the model has two error terms. While v_i is a symmetrical error, u_i is a nonnegative error variable. Thus, appropriate assumptions related to these two error terms must be addressed in order to use this model with greater confidence.

In general, it is being accepted that both error terms are not related with the explanatory variables in x_i where each v_i is distributed identically and independently from each u_i. Other assumptions required by a stochastic frontier model are zero average, constant variance, and lack of relation between noises and the inefficiency terms (Coelli et al, 1998: 245).

Under these assumptions, consistent estimators of *inclination* coefficients may be obtained by the use of ordinary least squares (OLS) method. However, the estimator for the constant term is downwards deviant. On the other hand, the constant being deviant expresses that the OLS estimators cannot be used in the calculation of measurements of technical efficiency. As a solution to this problem, a different method suggested by Winsten (1957) is defined as the *corrected ordinary least squares* (COLS) estimators. Another negotiable good solution is to accept some certain distributions with respect to both error terms, and accordingly to use the Maximum Likelihood (ML) method. As ML estimators have the required large sample features (such as asymptotic feature), they are generally preferred over other estimators such as COLS. Aigner et al. (1977) had obtained the ML estimators under the following assumptions:

$$v_i \sim iidN(0, \sigma_V^2) \text{ and } u_i \sim iidN^+(0, \sigma_U^2) \qquad (7)$$

The assumption with respect to the white noise expresses that the v_i s are being distributed normally as independent and identically with zero mean and σ_v^2 variance.

Assumption (7) expresses that the u_i s are being distributed semi-normally as independent and identically with σ_u^2 being the parameter of scale. *Probability density function* (PDF) for each u_i is the kurtic version of a normal random variable having zero mean and σ_U^2 variance.

In the $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\lambda^2 = \sigma_u^2 / \sigma_v^2 \geq 0$ terms, Aigner et al. (1977) had parametrized the log-likelihood function for a semi-normal model. When $\lambda = 0$, it indicates that there is no effect of technical inefficiency, and all deviations in frontier are arising from noise. For this operation, log-likelihood function can be expressed as follows:

$$\ln L(y \mid \beta, \sigma, \lambda) = -(I/2)\ln(\pi\sigma^2/2) + \sum_{i=1}^{I} \ln \Phi(-\varepsilon_i \lambda/\sigma) - (1/2\sigma^2)\sum_{i=1}^{I} \varepsilon_i^2 \quad (8)$$

Here, y may be expressed as a vector of log-outputs; $\varepsilon_i \equiv v_i - u_i - \ln y_i - x_i \beta$ may be expressed as a combined error term; and $\Phi(x)$ may be expressed as the cumulative distribution function (CDF) of a standard normal random variable whose combined error term is measured by x.

As is known, the maximization of a log-likelihood function is generally being performed by taking the first derivatives with respect to unknown parameters, and then by equalizing them to zero. However, first degree conditions cannot be satisfied to solve for β, σ and λ since (8) is not linear. Thus, maximization of the likelihood function should be performed by an iterative optimization process. This requires the selection of initial values for the unknown parameters, and systematic updating of these values until finding the values of the log-likelihood function. Battese and Cora (1977) had deemed more proper to parametrize the log-likelihood function in the terms of σ^2 and $\gamma = \sigma_u^2 / \sigma^2$. According to them, the parameter γ take values between 0 and 1. When $\gamma = 0$, all deviations in frontier are arising from white noise, and when $\gamma = 1$, all deviations are reflecting the technical inefficiency.

Within the framework of the determined purpose and method, two different production functions are estimated in the current study. First, the Cobb-Douglas production function can be expressed as follows:

$$lny = \alpha + \beta_1 \ln(l) + \beta_2 \ln(k1) + \beta_3 \ln(k2) + (v_i - u_i) \quad (9)$$

However, it is possible to square the inputs of the Model (9) and transform it into a translog production function. Accordingly, the SFA equation is created according to the translog production function and modelled as follows (Battese & Coelli, 1995: 328):

$$lny = \alpha + \beta_1 \ln(l) + \beta_2 \ln(k1) + \beta_3 \ln(k2) + \beta_4 \ln(k1^2) + \beta_5 \ln(k2^2) + \beta_6 \ln\,(l)^2 + \beta_7 \ln(k1 * k2) + time + (v_i - u_i) \quad (10)$$

Here (lny) represents subscribers; (l) represents the number of employees, $(k1)$ is the length of the steel pipeline, and $(k2)$ is the length of the polyethylene pipeline. Steel and polyethylene pipe lengths are proxies’ variables used instead of firms’ capital stocks. Another point to note is how the efficiency is calculated. If the efficiency research is output maximization (Production Maximization), the above compound error term calculation is valid, and $\varepsilon_i = \nu_i - u_i$. If the activity studies input minimization (Cost Function), then the equation $\varepsilon_i = \nu_i + u_i$ is valid for the error term (Avcı & Çağlar, 2016: 20-21).

When modelling according to the translog production function, the parameters of the variables (repetition) are included in the model. Due to the different parameters involved, translog production function is more flexible and sensitive, containing both curvilinear and linear vectors.

The SFA method considers the existence of statistical errors, and so it is greatly preferred in the calculation of Decision-Making Units (DMU) efficiency, because SFA does not link all inefficiencies exclusively to technical inefficiencies. It also considers the presence of measurement errors (Demir & Bilik, 2018: 32).

5. SFA Results

Cobb-Douglas production function estimates are presented in Table 3.

Table: 3
Cobb-Douglas Production Function Results

Parameter	Coef.	Std. Err.	z-value	P value	[95% Conf. Interval]
Cons.	-3.882843	.7919324	-4.90	0.000***	-5.435002 -2.330684
Ln(l)	.0169649	.0995762	0.17	0.865	-.1782007 .2121306
Ln(k1)	1.22116	.1109021	11.01	0.000***	1.003796 1.438524
Ln(k2)	-.1182207	.1028381	-1.15	0.250	-.3197797 .0833383
sigma_u	.3717624	.0432841			.2959106 .4670575
sigma_e	.4580767	.0183841			.4234252 .4955638
rho	.3971	.0610841			.2838821 .5197898
Log likelihood = -291.63987					
LR chi2(3) = 262.14				Prob > chi2 = 0.0000***	
LR test of sigma_u=0: chibar2(01) = 83.60 Prob >= chibar2 = 0.000***					
P < 0.10 (*) Significance is tested according to 10%, H_0 rejection and coefficient is significant P < 0.05 (**) Significance is tested according to 5%, H_0 rejection and coefficient is significant P < 0.01 (***) Significance is tested according to 1%, H_0 rejection and coefficient is significant					

According to results shown in Table 3, the effect of the number of employees (l) and the length of the polyethylene pipeline $(k2)$ on the number of subscribers were found to be statistically insignificant. Additionally, estimates based on the translog production function, which shows a more general and flexible structure in terms of parameters, are presented in Table 4.

Table: 4
Translog Production Function Results

Parameter	Coef.	Std. Err.	z-value	P value	[95% Conf. Interval]
Cons.	-29.62995	60.3578	-0.49	0.623	-147.9291 88.66916
Ln(l)	-1.010413	.6011018	-1.68	0.093*	-2.188551 .1677249
Ln(k1)	6.795093	1.853764	3.67	0.000***	3.161783 10.4284
Ln(k2)	-4.320939	1.361285	-3.17	0.002***	-6.989008 -1.65287
$Ln(1)^2$	.1097894	.0659701	1.66	0.096*	-.0195096 .2390884
$Ln(k1)^2$	-.4667788	.1248917	-3.74	0.000***	-.711562 -.2219955
$Ln(k2)^2$	-.1328706	.1061197	-1.25	0.211	-.3408614 .0751201
Ln(k1.k2)	.566565	.1954687	2.90	0.004***	.1834533 .9496767
Time	.0081134	.0285665	0.28	0.776	-.0478759 .0641028
sigma2	.5300433	.3355248			.1532812 1.832879
gamma	.6464315	.2226277			.2132037 .9250136
sigma_u2	.3426367	.3342849			-.3125498 .9978231
sigma_v2	.1874066	.0149699			.1580662 .216747
Wald chi2(8) = 598.62 Prob > chi2 = 0.0000***					
Log likelihood = -271.05112					
LR Test: 32.34868 Significance Level (dof. 0.05): 22.705					
P < 0.10 (*) Significance is tested according to 10%, H_0 rejection and coefficient is significant P < 0.05 (**) Significance is tested according to 5%, H_0 rejection and coefficient is significant P < 0.01 (***) Significance is tested according to 1%, H_0 rejection and coefficient is significant					

The validity of the translog production function has been tested with the Likelihood-Ratio test (LR test). As seen in Table 4, since the LR test statistic is greater than the 5%-critical value (32.34> 2.705), the hypothesis is accepted for the validity of the translog production function. Translog production function has a wider structure in terms of the parameters it contains. Both functions are estimated by the "Maximum Likelihood" technique. In this context, the question of which functional form is valid is answered by the "likelihood ratio test". This test process is expressed mathematically as follows (Kumbhakar et al., 2015: 106):

$$-2[L(H_0) - L(H_1)] \tag{11}$$

Here, $L(H_0)$ and $L(H_1)$ illustrate the LR test statistics of the restricted (Cobb-Douglas) and unrestricted (Translog) model, respectively. LR test results are given in Table 5. Accordingly, the H_0 hypothesis is rejected for the validity of the Cobb-Douglas functional form. Therefore, efficacy scores are obtained from the translog functional form.

Table: 5
LR Test Results

Test Statistics	Critic Value	Decision
32.34	2.705	H_0 Reject

Note: Critic values obtained by Kodde & Palm (1986).

As a result of the estimation made with the Maximum Likelihood method using the data between 2013 and 2018, the Wald statistic value is greater than the chi square (χ^2) distribution table value and is statistically significant. This provides evidence for the rejection of the null hypothesis, which states that there is no technical inefficiency. Thus, it could be argued that there is inefficiency in the model. In other words, it illustrates that there is technical inefficiency in DMUs between these years. However, in order to analyse the factors causing this inefficiency, it will be necessary to look at the gamma parameter. According to this, the approximate value of the deviations in the production limit function is 0.65 (u_i), this part is due to technical inefficiency, and the remaining 0.35 (v_i) part is due to random variables. This result shows that there are companies working with technical inefficiency, likely caused by their economic, administrative and operational activities. It is known that the parameters in the translog production function do not represent the output elasticity (Belotti et al., 2013). In this context, average elasticity values are calculated by linear combinations of the parameters. In order to interpret the translog production function parameters, the average elasticity values of the variables are calculated using the formulation below (Kumbhakar et al., 2015: 48):

$$\varepsilon_j = \frac{\partial lny}{\partial lnx_j} = \beta_j + \sum_k \beta_{jk} lnx_k + \beta_{j0}\mu \quad (12)$$

(y): dependent variable, (x_j): independent variable

The following formulation is used to calculate the level of return (RTS) according to the scale of all decision units with the help of Equation (12) (Kumbhakar et al., 2015: 49):

$$RTS = \sum_j \varepsilon_j = \sum_j (\beta_j + \sum_k \beta_{jk} lnx_k + \beta_{j0}\mu) \quad (13)$$

The average flexibility values and the RTS levels calculated according to (12) and (13) are presented in Table 6.

Table: 6
Average Elasticities Values ve RTS

Parameter	Coef.
Ln(l)	0.13
Ln(k1)	0.81
Ln(k2)	0.21
RTS (Increasing return of scale)	1.15

A 1% increase in the number of employees (l), steel pipeline ($k1$) and polyethylene ($k2$) pipeline length increases the number of residential subscribers by 0.13%, 0.81% and 0.21%, respectively. According to the RTS results, it is seen that natural gas distribution companies are making efforts to increase their returns to scale. According to the economic theory productivity analysis, this result shows that firms operate in the region of increasing return, which corresponds to the first region of production. The companies in this region work with increasing capacity, and ultimately can raise output by increasing inputs (Hünerli & Aydın, 2019: 141). In other words, the decision units in the analysis seem not to have yet reached maturity, and still have positive economies of scale. However, when they increase production, they will be able to eliminate their idle capacities. The long-term analysis shows that there is activity in the part where the envelope (long-term average cost) curve has a negative slope. Accordingly, it can be said that natural gas distribution companies are not able to distribute in sufficient quantity. Table 7 and Appendix 3 show the technical efficiency levels of each firm over years, and the firms are ranked according to their efficiency.

Table: 7
Firms' Efficiency Rate and Ranking by Translog Production Function

Rank	DMU	TE	Rank	DMU	TE
1	BURSA ŞEHİRİÇİ DGD	0,92	33	ARMAGAZ ARSAN MARMARA	0,66
2	ÇİNİGAZ DGD	0,91	34	ENERYA KONYA DGD	0,65
3	AKSA MALATYA DGD	0,90	35	ÇORDAŞ ÇORLU DGD	0,63
4	KARGAZ KARS ARDAHAN DGD	0,90	36	PALGAZ DGD	0,62
5	KARGAZ DGD	0,89	37	KIZILCAHAMAM DGD	0,62
6	ENERYA KAPADOKYA DGD	0,89	38	ARMADAŞ ARSAN MARAŞ DGD	0,62
7	İZGAZ İZMİT DGD	0,88	39	AKSA BİLECİK BOLU DGD	0,61
8	AKSA GEMLİK DGD	0,87	40	ENERYA EREĞLİ DGD	0,60
9	AKSA ÇUKUROVA DGD	0,87	41	SÜRMELİ DGD	0,59
10	AKSA BANDIRMA DGD	0,86	42	İGDAŞ İSTANBUL DGD	0,58
11	BAHÇEŞEHİR DGD	0,85	43	ENERYA AYDIN DGD	0,58
12	AKSA DÜZCE EREĞLİ DGD	0,84	44	AKSA AFYON DGD	0,57
13	AKSA ŞANLIURFA DGD	0,84	45	ENERYA ANTALYA DGD	0,56
14	POLGAZ POLATLI DGD	0,83	46	PALEN ENERJİ DGD	0,54
15	SAMGAZ DGD	0,82	47	AKSA SİVAS DGD	0,53
16	AKSA ORDU GİRESUN DGD	0,81	48	SELÇUK DGD	0,51
17	İZMİRGAZ ŞEHİR İÇİ DGD	0,81	49	ENERYA KARAMAN DGD	0,50
18	UDAŞ UŞAK DGD	0,81	50	AKSA ELAZIĞ DGD	0,48
19	ENERYA ERZİNCAN DGD	0,81	51	AKMERCAN ADIYAMAN DGD	0,48
20	AKSA KARADENİZ DGD	0,80	52	KIRGAZ KIRIKKALE-KIRŞEHİR DGD	0,48
21	AKSA M.K.PAŞA SUSURLUK K.	0,79	53	AGDAŞ ADAPAZARI DGD	0,47
22	TOROSGAZ ISPARTA BURDUR	0,79	54	AKMERCAN DELTA DGD	0,45
23	AKSA VAN DGD	0,79	55	İNEGÖL DGD	0,44
24	AKSA SİİRT BATMAN DGD	0,78	56	ESGAZ ESKİŞEHİR ŞEHİRİÇİ DGD	0,43
25	AKSA GÜMÜŞHANE BAYBURT	0,78	57	DİYARBAKIR DGD	0,42
26	BAŞKENT DGD	0,77	58	AKMERCAN BATIKAR DGD	0,38
27	AKSA BALIKESİR DGD	0,76	59	AKSA TOKAT AMASYA DGD	0,33
28	ENERYA AKSARAY DGD	0,74	60	KAYSERİGAZ KAYSERİ DGD	0,31
29	GAZDAŞ GAZİANTEP DGD	0,73	61	AKMERCAN GEPA DGD	0,29
30	TRAKYA BÖLGESİ DGD	0,72	62	ÇORUM DGD	0,27
31	AKSA MANİSA DGD	0,70	63	AKSA ÇANAKKALE DGD	0,18
32	ENERYA DENİZLİ DGD	0,68	TE: Technical Efficiency, DMU: Decision Making Units		

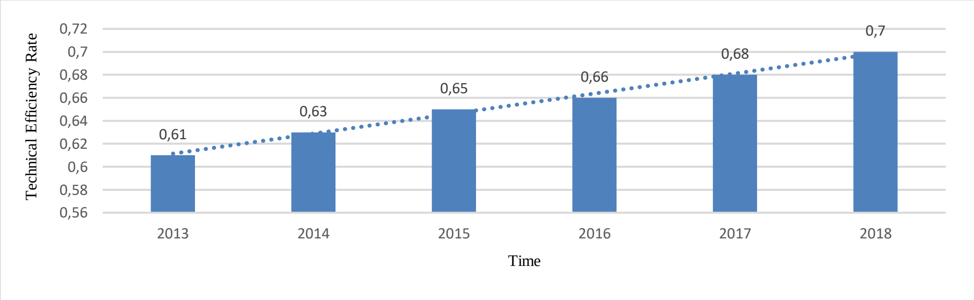
When the firm efficiency levels are analysed according to the estimation of the translog production function, the five most inefficient firms were Çorum DGD with 0.18, Akmercan GEPA DGD with 0.29, Kayserigaz with 0.31, Aksa Tokat with 0.33 and Akmercan Batıkar with 0.38. Analysis of the input and output values of these five most inefficient natural gas distribution companies shows that the length of the polyethylene and steel pipeline, number of personnel, and the rate of increase in these inputs were below long-term industry averages.

The five most effective companies according to the estimation of the translog production function are as follows: Bursa Şehiriçi DGD with 0.92, Çinigaz with 0.91, Aksa Malatya DGD with 0.90, Kargaz Kars Ardahan DGD with 0.90 and Kargaz DGD with 0.89. For the five most effective companies, the output growth rate is higher than the input growth rate, which implies increasing returns to scale. Although no firm is fully effective, as can be seen in Appendix 1, the efficiency of all firms is gradually increasing.

Figure 1 presents the average efficiency levels of the natural gas distribution industry over time. The average efficiency level of the sector in the period of analysis (2013-2018) is

0.66 (66%). The efficiency level increased from 0.61 (60%) in 2013 to 0.70 in 2018 i.e., the potential output levels of companies converged over time. Accordingly, it can be stated that the increase in firms' inputs resulted in a greater increase in output in the examined period, and this increase in scale contributes to a more competitive market structure in the natural gas distribution market.

Figure: 1
Average Technical Efficiency by Time (2013-2018)



6. Conclusion and Suggestions

Previous studies dealing with the efficiency of the distribution sectors (electricity, water, natural gas, telecommunications) have been mainly conducted through a DEA analysis. However, the current study aimed at presenting a different perspective by including an error term into the analysed model. To this end, efficiency measurement was carried out by SFA, which is a parametric method over the production function that separates the error term in itself. The findings of the present study indicate that a large part of inefficiency in the natural gas distribution sector in Turkey is actually driven by economic and administrative activities of the firms. The appropriate form of the selected production function was translog production function, which contains more detailed, more flexible and interaction parameters compared to a Cobb-Douglas production function.

The results of the analyses indicate that no firm was working with full efficiency. In addition, it was found that inefficiency was due to technical inefficiency rather than measurement errors. Bursa Şehiriçi Natural Gas distribution firm has the highest efficiency (the lowest inefficiency), and Aksa Çanakkale Natural Gas distribution firm exhibits the lowest efficiency. In the period of analysis, 1% increase in inputs increases the output by 1.15%. Therefore, the sector works with increasing returns to scale. The combined effect of Polyethylene Pipeline ($k2$) and Steel Pipeline ($k1$) variables, considered as production inputs in the study, is almost 1.02%. It is also revealed that physical capital accumulation increases production, in accordance with the production theory. Therefore, it is seen that investment in pipelines will rapidly increase total natural gas distribution. Polyethylene pipeline may be more appropriate to the geologic and geographic conditions of Turkey, and therefore would be a more suitable investment tool for the reduction of economic costs experienced by the inefficient firms.

In summary, if the results are evaluated as a whole, it can be said that although no firm runs with full efficiency in the sector, the sector as a whole works under increasing returns. Thus, not all hypotheses in the study can be rejected. This shows that the natural gas distribution industry in Turkey has not reached a sufficient maturity or its optimal capacity. Consequently, while firms' scaling up, investing, and increasing their inputs will increase the average efficiency of the sector in the short-term, reducing average costs will have a lasting effect in the long-term. These long and short-term measures will contribute to a more effective distribution and consumption of this scarce resource, and thus will most probably reduce Turkey's energy-dependency.

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APPENDIX 1:
Skewness/Kurtosis Tests

	Percentiles	Smallest	
1%	-1.550387	-5.837698	
5%	-.3063836	-2.555105	
10%	-.1516989	-2.092994	Obs 378
25%	-.0503882	-1.550387	Sum of Wgt. 378
50%	.0140411		Mean -1.33e-10
		Largest	Std. Dev. .4187191
75%	.0975712	1.132713	
90%	.1872883	1.184821	Variance .1753257
95%	.3682765	1.201678	**Skewness -7.980426**
99%	1.132713	1.23412	Kurtosis 107.4695

APPENDIX 2:
Skewness/Kurtosis Tests for Normality

Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	chi2(2)	Prob>chi2
e	378	**0.0000**	0.0000	580.20	0.0000

APPENDIX 3:
Technical Efficiency According to the Firm by Time

Rank	DMU	t	TE	Avg. TE	Rank	KVB	t	TE	Avg. TE	Rank	DMU	t	TE	Ort. TE
53	AGDAŞ ADAPAZARI GAZ DAĞITIM	2013	0,40	0,47	47	AKSA SİVAS DOĞAL GAZ DAĞITIM	2013	0,47	0,53	34	ENERYA KONYA GAZ DAĞITIM A.Ş.	2013	0,60	0,65
		2014	0,43				2014	0,49				2014	0,62	
		2015	0,45				2015	0,52				2015	0,64	
		2016	0,48				2016	0,54				2016	0,66	
		2017	0,50				2017	0,56				2017	0,68	
		2018	0,53				2018	0,58				2018	0,69	
51	AKMERCAN ADIYAMAN DOĞAL GAZ DAĞITIM	2013	0,42	0,48	13	AKSA ŞANLIURFA DOĞAL GAZ DAĞITIM	2013	0,81	0,84	56	ESGAZ ESKİŞEHİR ŞEHİRİÇİ DOĞAL GAZ	2013	0,36	0,43
		2014	0,44				2014	0,82				2014	0,39	
		2015	0,47				2015	0,83				2015	0,41	
		2016	0,49				2016	0,84				2016	0,44	
		2017	0,51				2017	0,85				2017	0,46	
		2018	0,54				2018	0,86				2018	0,49	
58	AKMERCAN BATIKAR DOĞAL GAZ	2013	0,31	0,38	59	AKSA TOKAT AMASYA DOĞAL GAZ	2013	0,27	0,33	29	GAZDAŞ GAZİANTEP DOĞAL GAZ	2013	0,69	0,73
		2014	0,34				2014	0,29				2014	0,70	
		2015	0,36				2015	0,32				2015	0,72	
		2016	0,39				2016	0,34				2016	0,73	
		2017	0,41				2017	0,37				2017	0,75	
		2018	0,44				2018	0,39				2018	0,76	
54	AKMERCAN DELTA DOĞALGAZ	2013	0,39	0,45	23	AKSA VAN DOĞAL GAZ DAĞITIM	2013	0,76	0,79	42	İGDAŞ İSTANBUL GAZ DAĞITIM SAN.	2013	0,52	0,58
		2014	0,41				2014	0,77				2014	0,55	
		2015	0,44				2015	0,78				2015	0,57	
		2016	0,46				2016	0,80				2016	0,59	
		2017	0,48				2017	0,81				2017	0,61	
		2018	0,51				2018	0,82				2018	0,63	
61	AKMERCAN GEPA DOĞAL GAZ	2013	0,23	0,29	38	ARMADAŞ ARSAN MARAŞ DOĞAL GAZ	2013	0,56	0,62	55	İNEGÖL GAZ DAĞITIM SAN.	2013	0,38	0,44
		2014	0,26				2014	0,59				2014	0,40	
		2015	0,28				2015	0,61				2015	0,43	
		2016	0,30				2016	0,63				2016	0,45	
		2017	0,33				2017	0,65				2017	0,47	
		2018	0,35				2018	0,66				2018	0,50	
44	AKSA AFYON DOĞAL GAZ DAĞITIM	2013	0,51	0,57	33	ARMAGAZ ARSAN MARMARA	2013	0,61	0,66	7	İZGAZ İZMİT GAZ DAĞITIM	2013	0,86	0,88
		2014	0,54				2014	0,63				2014	0,87	
		2015	0,56				2015	0,65				2015	0,88	
		2016	0,58				2016	0,67				2016	0,89	
		2017	0,60				2017	0,69				2017	0,89	
		2018	0,62				2018	0,70				2018	0,90	
27	AKSA BALIKESİR DOĞAL GAZ DAĞITIM	2013	0,73	0,76	11	BAHÇEŞEHİR GAZ DAĞITIM	2013	0,83	0,85	17	İZMİRGAZ ŞEHİR İÇİ DOĞALGAZ	2013	0,78	0,81
		2014	0,74				2014	0,84				2014	0,80	
		2015	0,76				2015	0,85				2015	0,81	
		2016	0,77				2016	0,86				2016	0,82	
		2017	0,78				2017	0,87				2017	0,83	
		2018	0,80				2018	0,88				2018	0,84	
10	AKSA BANDIRMA DOĞAL GAZ DAĞITIM	2013	0,84	0,86	26	BAŞKENT DOĞALGAZ DAĞITIM	2013	0,74	0,77	5	KARGAZ DOĞAL GAZ DAĞITIM	2013	0,87	0,89
		2014	0,85				2014	0,75				2014	0,88	
		2015	0,86				2015	0,77				2015	0,89	
		2016	0,87				2016	0,78				2016	0,90	
		2017	0,88				2017	0,79				2017	0,90	
		2018	0,88				2018	0,80				2018	0,91	
39	AKSA BİLECİK BOLU DOĞALGAZ DAĞITIM	2013	0,55	0,61	1	BURSA ŞEHİRİÇİ DOĞAL GAZ DAĞITIM	2013	0,91	0,92	4	KARGAZ KARS ARDAHAN DOĞAL	2013	0,88	0,90
		2014	0,58				2014	0,91				2014	0,89	
		2015	0,60				2015	0,92				2015	0,90	
		2016	0,62				2016	0,92				2016	0,90	
		2017	0,64				2017	0,93				2017	0,91	
		2018	0,66				2018	0,93				2018	0,91	
63	AKSA ÇANAKKALE DOĞAL GAZ	2013	0,13	0,18	2	ÇİNİGAZ DOĞAL GAZ DAĞITI	2013	0,89	0,91	60	KAYSERİGAZ KAYSERİ DOĞALGAZ	2013	0,25	0,31
		2014	0,15				2014	0,90				2014	0,28	
		2015	0,17				2015	0,91				2015	0,30	
		2016	0,19				2016	0,91				2016	0,33	
		2017	0,21				2017	0,92				2017	0,35	
		2018	0,23				2018	0,92				2018	0,38	
9	AKSA ÇUKUROVA GAZ DAĞITIM A.Ş.	2013	0,84	0,87	35	ÇORDAŞ ÇORLU DOĞALGAZ DAĞITIM	2013	0,58	0,63	52	KIRGAZ KIRIKKALE-KIRŞEHİR DOĞAL	2013	0,42	0,48
		2014	0,85				2014	0,60				2014	0,44	
		2015	0,86				2015	0,62				2015	0,46	
		2016	0,87				2016	0,64				2016	0,49	
		2017	0,88				2017	0,66				2017	0,51	
		2018	0,89				2018	0,67				2018	0,54	
12	AKSA DÜZCE EREĞLİ DOĞAL GAZ	2013	0,82	0,84	62	ÇORUM DOĞAL GAZ DAĞITIM SAN	2013	0,21	0,27	37	KIZILCAHAMAM DOĞALGAZ DAĞITIM	2013	0,57	0,62
		2014	0,83				2014	0,23				2014	0,59	
		2015	0,84				2015	0,25				2015	0,61	
		2016	0,85				2016	0,28				2016	0,63	
		2017	0,86				2017	0,30				2017	0,65	
		2018	0,87				2018	0,33				2018	0,67	

50	AKSA ELAZIĞ DOĞALGAZ DAĞITIM	2013	0,42	0,48	57	DİYARBAKIR DOĞAL GAZ DAĞITIM	2013	0,36	0,42	46	PALEN ENERJİ DOĞAL GAZ DAĞITIM	2013	0,48	0,54
		2014	0,44				2014	0,38				2014	0,51	
		2015	0,47				2015	0,41				2015	0,53	
		2016	0,49				2016	0,43				2016	0,55	
		2017	0,52				2017	0,46				2017	0,57	
		2018	0,54				2018	0,48				2018	0,60	
8	AKSA GEMLİK DOĞAL GAZ DAĞITIM	2013	0,85	0,87	28	ENERYA AKSARAY DOĞALGAZ DAĞITIM	2013	0,70	0,74	36	PALGAZ DOĞAL GAZ DAĞITIM	2013	0,57	0,62
		2014	0,86				2014	0,72				2014	0,59	
		2015	0,87				2015	0,73				2015	0,61	
		2016	0,88				2016	0,75				2016	0,63	
		2017	0,88				2017	0,76				2017	0,65	
		2018	0,89				2018	0,77				2018	0,67	
25	AKSA GÜMÜŞHANE BAYBURT	2013	0,74	0,78	45	ENERYA ANTALYA GAZ DAĞITIM A.Ş.	2013	0,50	0,56	14	POLGAZ POLATLI DOĞAL GAZ	2013	0,80	0,83
		2014	0,76				2014	0,53				2014	0,81	
		2015	0,77				2015	0,55				2015	0,82	
		2016	0,79				2016	0,57				2016	0,83	
		2017	0,80				2017	0,59				2017	0,84	
		2018	0,81				2018	0,61				2018	0,85	
20	AKSA KARADENİZ DOĞAL GAZ	2013	0,77	0,80	43	ENERYA AYDIN DOĞAL GAZ DAĞITIM	2013	0,52	0,58	15	SAMGAZ DOĞAL GAZ DAĞITIM	2013	0,80	0,82
		2014	0,78				2014	0,55				2014	0,81	
		2015	0,79				2015	0,57				2015	0,82	
		2016	0,81				2016	0,59				2016	0,83	
		2017	0,82				2017	0,61				2017	0,84	
		2018	0,83				2018	0,63				2018	0,85	
3	AKSA MALATYA DOĞAL GAZ DAĞITIM	2013	0,88	0,90	32	ENERYA DENİZLİ GAZ DAĞITIM	2013	0,64	0,68	48	SELÇUK DOĞAL GAZ DAĞITIM	2013	0,45	0,51
		2014	0,89				2014	0,66				2014	0,47	
		2015	0,90				2015	0,68				2015	0,50	
		2016	0,90				2016	0,69				2016	0,52	
		2017	0,91				2017	0,71				2017	0,54	
		2018	0,92				2018	0,73				2018	0,57	
31	AKSA MANİSA DOĞAL GAZ DAĞITIM	2013	0,66	0,70	40	ENERYA EREĞLİ GAZ DAĞITIM	2013	0,55	0,60	41	SÜRMELİ DOĞAL GAZ DAĞITIM	2013	0,53	0,59
		2014	0,68				2014	0,57				2014	0,56	
		2015	0,70				2015	0,59				2015	0,58	
		2016	0,71				2016	0,61				2016	0,60	
		2017	0,73				2017	0,63				2017	0,62	
		2018	0,74				2018	0,65				2018	0,64	
21	AKSA MUSTAFAKEMALPAŞA SUSURLUK KARACABEY	2013	0,76	0,79	19	ENERYA ERZİNCAN GAZ DAĞITIM	2013	0,78	0,81	22	TOROSGAZ ISPARTA BURDUR	2013	0,76	0,79
		2014	0,78				2014	0,79				2014	0,77	
		2015	0,79				2015	0,80				2015	0,78	
		2016	0,80				2016	0,82				2016	0,80	
		2017	0,81				2017	0,83				2017	0,81	
		2018	0,82				2018	0,84				2018	0,82	
16	AKSA ORDU GİRESUN DOĞAL GAZ	2013	0,79	0,81	6	ENERYA KAPADOKYA DOĞAL GAZ DAĞITIM	2013	0,89	0,89	30	TRAKYA BÖLGESİ DOĞAL GAZ	2013	0,68	0,72
		2014	0,80				2014	0,90				2014	0,70	
		2015	0,81				2015	0,90				2015	0,72	
		2016	0,82				2016	0,91				2016	0,73	
		2017	0,83				2017	0,91				2017	0,75	
		2018	0,84				2018	0,92				2018	0,76	
24	AKSA SİİRT BATMAN DOĞAL GAZ DAĞITIM	2013	0,74	0,78	49	ENERYA KARAMAN DOĞAL GAZ DAĞITIM	2013	0,44	0,50	18	UDAŞ UŞAK DOĞALGAZ DAĞITIM	2013	0,78	0,81
		2014	0,76				2014	0,47				2014	0,79	
		2015	0,77				2015	0,49				2015	0,81	
		2016	0,79				2016	0,51				2016	0,82	
		2017	0,80				2017	0,54				2017	0,83	
		2018	0,81				2018	0,56				2018	0,84	