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Measuring the efficiency of firms listed in Tehran Stock Exchange Using Stochastic Frontier Production Function based on accounting data

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Abstract
One of the most important effective elements in economic growth is the efficiency of manufacturing units. Therefore, measuring the efficiency of firms is necessary in order to increase efficiency in future planning courses. In the current research, using Stochastic Frontier Production Function, the efficiency of firms in Tehran Stock Exchange has been measured. In the above method, the efficient frontier is determined by using the Trans log production function, and the efficiency of each firm measured by the efficient frontier. The most important superiority of Stochastic Frontier Production Function is to specify the role of random and environmental elements (out of firm authorities) and inter-organizational elements (in-firm authorities) to assess the inefficiency of firms as compared to other methods. Thus, 105 firms were selected using maximum likelihood method in 2008-2017 to evaluate the research model. Results indicated that the minerals industry and cement industry with the averages of 53% and 90% had the least and most efficiency values, respectively. Separating the inefficiency values showed that the food industry and chemicals industry had the least and most inefficiency resulting from the firm authorities as 33.6% and 95.2%, respectively. According to research results, financial analysts and investors are recommended to rank the efficiency and assess the performance based on the firm authorities. Due to the importance of efficiency measurement in operational auditing, the auditors are recommended to use the current research model to assess the firm's efficiency. Also, Organization of Industries and Mines is suggested to tackle the obstacles after identifying the elements out of firm authorities which affect the inefficiency in the firms.

Keywords: Efficiency, Stochastic Frontier Production Function, Trans log Production Function.

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Introduction

Despite constant scientific developments, human beings have been always facing the issue of scarce resources. Therefore, they attempt to obtain the maximum output of the available resources. Using assessment systems to ensure exploiting resources properly is necessary for every economic activity. So, individuals try to gain access to information on economic segments performance using different paths. Accounting is an important way of information channel in every organization. Managers use accounting information as an important tool to make decisions on how to allocate the resources and to ensure the proper way of exploiting them. Information reduces uncertainty and improves decision making. When an organization faces limited resources, this issue becomes more important (Hadian et al, 2009).

Using modern and advanced techniques is an important tool to improve performance. Applying these techniques enabled managers to change directions in different situations, increase growth in one area or reduce it in other areas. Which in turn the manager can react to future risks, and make the most of the facing situations (Daneshvar, 2006). Recently, changes in technology customer's needs and increased competition have yielded great changes in using modern techniques (James, 2004). On the other hand, investors are always seeking the best investment occasions to gain the highest yields. So they begin to assess and rate the firms.

Assessing firms is multifaceted. Sink and Tuttle (1989), state that organization performance is the result of the relationships between seven performance criteria including effectiveness, efficiency, quality, productivity, working life standards, innovation and profitability. Although the industry has changed rapidly since the proposal of this model, the introduced criteria are still of paramount importance in assessing organizational performance. Efficiency as a performance assessment criterion indicates utilizing available resources in a firm. The concept of Pareto optimality indicates the most efficient state of allocations in the economy so that scholars consider standard deviation from Pareto optimality as inefficiency criteria.

Based on the above-mentioned explanations, the issue of measuring and assessing performance is of paramount importance. Management specialists believe that if you can't measure performance, you cannot manage it (Armstrong, 2006). Performance measurement helps to evaluate such subjects as the quality of resource utilization, the level of performance, weaknesses and failures, deviations from the developed programs, discovering approaches to improve productivity and recommend the needed reforms. On the other hand, the role of environmental factors has always been discussed in performance evaluation (Khajavi et al., 2017). Managers generally announce environmental factors such as failures but if successful, they will express their abilities. Therefore, it is necessary to clarify the role of each factor separately. Research in Iran has only measured efficiency, but in the present study, after measuring the efficiency of firms, the contribution of inter-organizational factors and environmental factors to the occurrence of inefficiency is calculated separately using the Stochastic Frontier Function. The research results help shareholders and investors evaluate the performance of TSE (Tehran stock exchange). CEO can also evaluate the performance of departments, branches and units using the research model. In the second part, the concept of efficiency, its measurement criteria and the literature review will be explained briefly. In the third part, the stochastic frontier function model will be introduced. And in the fourth part, the efficiency of the selected sample from listed firms in Tehran Exchange using accounting variables is measured and finally, the result will be reported in the fifth part.

Research Background

Efficiency is assessed in three fields, including engineering, management and economic. This term was first used in physics and thermodynamics and then, used in other fields. In physics, efficiency is measured as the ratio of actual output by potential output is obtained and its value is always less than one. In management, besides the physical inputs and assets, human capital is also taken into consideration. In economics, efficiency is measured as the ratio of the output to the input (Zarra-Nezhad et al 2012). In this case, firms which use fewer inputs to produce its goods and services are efficient. The constant growth of firms depends on increasing the level of efficiency and productivity. In neoclassic growth models, increasing factors of production, based on the law of diminishing returns, will not yield constant growth. In fact, modern long-term development plans, increasing the level of efficiency and productivity have gained great importance (Harif azadeh and Basirat, 2011).

Although different definitions of the efficiency are proposed, their common characteristics are to combine specific inputs to achieve the utmost yields (Amiri and Raeis Safari, 2005). Over time, measuring efficiency and its changes will be useful for the quality of allocating resources, the level of performance, weaknesses and failures, deviations from the programs developed, discovering improving optimality methods and reformation suggestions. According to these definitions, in 1957 based on Debreu and Koopmans (1951) studies, Farrell for the first time attempted to measure the efficiency. He defined three types of efficiency: Technical Efficiency, Allocative Efficiency and Economic Efficiency. Technical Efficiency is defined as the ability of a firm to maximize the production based on the available resources. Allocative Efficiency explains a firm's ability to combine factors of production optimally based on the price of the factors. And (Total) Economic Efficiency is obtained by multiplying Technical Efficiency and Allocative Efficiency (Coelli, 1998).

Financial ratios and frontier methods are used for measuring efficiency. To analyse financial performance, the financial ratio is extracted from financial statements issued by accounting systems. And these ratios are compared with the performance index. According to the Normative Theory, financial ratios are compared to the base (annual average or industry indices) and then its performance will be evaluated. Based on positive Theory, financial ratios are used to predict performance, bankruptcy, and risk assessment (Shanmari and Solimi, 1998).

Although the studies have shown that the financial ratios are relatively successful at achieving its purpose, it has some weaknesses and limitations, as smith and Burner (**1990)** argue, one or some ratios cannot provide sufficient information about the various aspects of performance. Choosing the base or an index is another problem off financial ratios, in other words, there is not a fixed and reliable standard to use as a base for comparing (Malhotra, 2008). Other researchers also criticised the accounting ratio as performance assessment criteria. If focuses on one of the financial ratios, there may be a tool for imposing pressure and producing a negative reaction to organizational controls. For example, if the proportion of earnings per capita is considered as the sole performance assessment criteria, it will force the manager to reduce the number of staff to demonstrate optimal performance. On the other hand, syndicates oppose the reduction of the staff. This internal contradiction will reduce the efficiency of the organization. With decentralization policy and separate performance assessment, each segment is considered separate of the other, so that it would cause conflict among those sections and each segment will transfer the pressure to other segments. Consequently, the benefits of the organization will be replaced by those of the individual units and the spirit of cooperation disappears. The inflexibility of the accounting standards is another subject of criticism. Despite the fact that firms have different situations and the business environment is constantly changing, accounting standards for firms with different status are fixed for several fiscal periods. (Kashani-pour and Ghazizadeh, 2008, Khajavi et al, 2010).

The problems of financial ratio methods impelled researchers to seek new methods of measuring efficiency. For this purpose, the economists innovated the frontier methods (Kashani-pour and Ghazizadeh, 2008). Based on microeconomics theories, production function which, by using technology and specific inputs, show the maximum amount of possible productions. This indicates the frontier production function and can be measured using parametric and nonparametric techniques. In both methods, in the first step, the efficient frontier is determined and then efficiency levels of each firm are benchmarked against the efficient frontier. Many studies show the advantage of the frontier analysis methods over other methods (Siriopoulos and Tziogkidis, 2010).

Nonparametric or Data Envelopment Analysis (DEA) is based on deterministic and non-random and they also employ linear planning methods. In this method, there's no error term and it is supposed that the effects of the variables and identifiable without any bias (Joo et al. 2013). In mathematic modelling, when solving the model, it will be shown whether the firm is on the curve or not. So, Linear planning problems for every firm will be solved and at the final step, the inefficient firms will be separated from inefficient firms (Emami Meibodi, 2000).

One of the limitations of DEA is the relative efficiency of performance, in other words, firms may not be efficient practically but they may obtain the highest rates of efficiency among investigated firms (Ranjbar, 2011). Other limitations of the nonparametric method include non-testability and to separate of the residuals. This means that econometric and statistical models are not used in DEA and it is not possible to test and accept or reject hypotheses. And each derivation from production efficiency frontier curve is measured and provided as inefficiency. Whereas it may be part of the deviation from environmental factors and not from the performance of the firm (Ilieva, 2003).

The parametric method is the latest form of the frontier which is measured using production functions such as Transloug and Cab Douglass. Function's parameters are estimated by utilizing econometric methods (Mehrara and Abdi 2014). In a way that uncontrollable factors and specification are modelled independently of the firm's inefficiency. In the methodology section separating error term from inefficiency will be explained. In the next section, the literature review will be provided.

Piesse and Thirtle (2000) investigated the level of efficiency, technological changes and productivity in industrial and agricultural firms in Hungry. They measured the level of efficiency during 1998_1991 by using stochastic frontier production function and then tested the efficiency factors. According to their findings, mismanagement and substitution conflicts among production agents were two important factors affecting inefficiency. In addition, paying the state firms subsidy resulted in decreased efficiency. The positive effects of firm 'efficiency were influenced by a technological recession in that period in a way that the total optimality rate decreased.

Deliktas et al (2001) investigated the changes in production factors in selected industries using DEA method in Turkey. The results indicate that in spite of an increase in total optimality, it is low. The increased efficiency in both public and private sectors played an important role in increasing the production factors optimality.

Giovannini and Nezu (2001) studied the efficiency of Manufacturing Industries in Economic Cooperation Organization (ECO) during 1994_2000. The results suggest that the level of efficiency of these countries were 88% and automobile and, conversion industries had the highest and lowest level of efficiency respectively. Factors such as level of professional staff, activity area and better access to financial markets affected the performance of these industries.

Goaied and Mouelhi (2002) measured the efficiency of garment, knitting and leather industry by using econometrics techniques and panel data in Tunisia. The results suggest that firms experienced a technological regression during the period1983_1994 which resulted in decreased productivity rates. And exporting firms had more efficiency.

Faria et al (2005) estimated the efficiency of public and private water supplying companies using Cab Douglass production function applying maximum like hood estimation in Brazil. The results show that the efficiency of private companies was greater than public companies.

Sharma et al (2007) estimated technical efficiency and production factors productivity in the USA using stochastic frontier production function during 1997_2007. According to their findings, the level of efficiency was high on average and Alaska had the highest level of efficiency.

Diewert (2008) during 1990_2006 studied efficiency changes in USA manufacturing industries. Their findings indicated that average efficiency level experienced a good increase and from 76% at the beginning of the study increased to 92% in 2006, Increased between different sectors relations are among factors affecting increased efficiency of the industries.

Barvo (2010) compared technical efficiency and technological gap using the stochastic frontier method in Argentina, Chile and Uruguay in1996_2003. The results suggest that average technical efficiency for each country was 8.72, 8.65 and 4.73 present respectively. And there was a significant difference between technological efficiency and production rate in these countries.

Rostami et al (2011) in a study titled Financial Performance Evaluation of Banks Listed in Tehran Stock Exchange, used profitability, liquidity, ... criteria to evaluate efficiency using the TOPSIS method and DEA model. The results show that KarAfarin Bank, Mellat Bank, Persian Bank had the lowest distance (highest efficiency) and Saderat Bank the highest distance (the lowest efficiency) from the ideal situation respectively.

Helhel (2015) In a study compared financial performance of foreign and domestic banks during 2009_2013 in Georgia. ROA and ROE and net profit margin were used as criteria for performance assessment. The results suggest no difference between domestic and foreign banks' profitability.

Pankaj et al (2018) investigated different methods of optimality for transportation and industry using DEA. The number of inputs and outputs was the basis for assessing transportation network. by combining DEA and AHP methods in the proposed model, they obtainable the amount and profitability rate for each vehicle which is more realistic than other models.

Numerous studies have been conducted on the electricity production and distribution industry. Hattori (2002) investigated the technical performance of electricity firms in the USA and Japan during 1997_1982 using stochastic frontier and translog function. The results show that after controlling the environmental variable, Japanese companies are more efficient. Fallahi and Ahmadi (2006), by using Battese and cooli (1992) model of error correction, estimated the efficiency of electricity despatching firms in Khorasan Province. Their findings suggest that load coefficient and density of customers have a negative relationship with the cost of electricity distribution companies in the province and on the other hand, the volume of electricity delivered to customers has a positive relationship with the cost of electricity distribution firms

Hess and Cullman (2007) in a study using 99 French companies and 77 German firms stated that companies in urban areas have higher efficiency. Investing in underground cables has increased technical efficiency of these firms.

Sueyoshi and Goto (2009) by estimating Transloug function for electricity companies in Japan during 1983_2003, measured some economic scales including optimality growth, technical changes and economics of scale. The findings suggest the growth of optimality after deregulation. Pe´rez-Reyes and Tovar (2009) In a study, investigated efficiency and change in the productivity of Peruvian electricity distribution companies during 1996_2006. Their findings suggest that the company's efficiency and productivity increased after reformations and restructuration. Huang et al (2009) for Taiwanese electricity distribution companies concluded that average efficiency for the group with higher circuit density is significantly better than circuits with low density because economies of scale have reduction it.

Methodology

This study in terms of purpose is applied research and, in terms of data collection method is Semi experimental after-event research in the field of proof accounting research. In this research, the efficiency of firms is measured using econometrics models and microeconomic theories. In stochastic frontier production function, the place of the efficient firms on the curve is estimated by using econometric models and concerning that frontier, the inefficiency of each firm will be determined. In random frontier models, the differences between actual production and efficient frontier production are separated. Some of the derivations are caused by factors out of firm authorities, factors (for instance luck or macroeconomic factors) measurement errors and other variables which are excluded from the model and Some parts of the inefficiency are due to performance of the factors in firm authorities. Early empirical studies, mainly conducted by Pitt and Lee (1981), used a two-stage method to estimate the parameters and test the hypothesis. In the first step, the inefficiency effect assumed to be distributed evenly is estimated from the random frontier. In the second step, the effects of predicted inefficiency as a dependent variable on the independent explanatory variables are regressed. The limitation of model Pitt and Lee has been criticized because the assumptions of two-step analysis are different. On the one hand, in the first stage, it is assumed that the effects of inefficiency are distributed evenly, while in the second stage it acts as a dependent variable. Criticisms led to the use of one-step methods. In one-step methods the conditional distribution u is conditional on the value of the random variable $\varepsilon = v - u$ in the likelihood function (Fenn, 2008).

Frontier model is simply defined as

$$C_{it}=\beta_1 X_{it}+\varepsilon_{it} \qquad (1)$$

$$\varepsilon_{it} = v_{it} + u_{it} \qquad (2)$$

In mode 1, C is revenue or input and X is production factors, and in model 2, U_{it} is inefficiency (factors in firm authorities) and V_{it} shows the random part (factors out of firm authorities). The econometric logic of residual value separation is the different behavioral properties of the two variables, in a way that by defining a model for U_{it}, it can be Separated from V_{it}. According to distribution theories and independence of U_{it} and V_{it}, the joint density for the two variables will be obtained through equation 3.

$$f(v,u)=\frac{\exp-\frac{1}{2}\{[v^2/\sigma_v^2]+[(u-z\delta)^2/\sigma^2]\}}{2\pi\sigma\sigma_v\phi[z\delta/\sigma]} \quad ,u\geq 0 \tag{3}$$

For model 3 simplifying purposes, indexes i and t are omitted and □ (0) shows cumulative distribution function of a random variable. Through joint density ε=v+u and u by definition of $\mu_* = \frac{\sigma_V^2 z\delta+\sigma^2\epsilon}{\sigma_V^2+\sigma^2}$ find density function will be

$$f(\varepsilon)=\frac{\exp-\frac{1}{2}\{(\varepsilon-z\delta)^2/(\sigma_v^2+\sigma^2)\}}{\sqrt{2\pi}(\sigma^2+\sigma_v^2)^{1/2}[\phi(z\delta/\sigma)/\phi(\mu_0/\sigma_0)]} \tag{4}$$

For model 4 conditional density function u with having ε will be

$$f(u\,|\,\varepsilon)=\frac{\exp-\frac{1}{2}[(u-\mu_0)^2/\sigma_0^2]}{\sqrt{2\pi}\sigma_0\phi(\mu_0/\sigma_0)} \quad , \quad u\geq 0 \tag{5}$$

Conditional expectation e^{-u} That is, the criterion of efficiency is assumed to be ε according to 6 models

$$E(e^{-U}\,|\,\varepsilon)=\{\exp[-\mu_0+1/2\sigma_0^2]\}\{\phi[(\mu_0/\sigma_0)-\sigma^0]/\phi(\mu_0/\sigma_0)\} \tag{6}$$

Density function in the first equation by using the fourth equation will be model7.

$$f(c_u)=\frac{\exp-\frac{1}{2}\left\{\frac{(c_u-X_u\beta-z_u\delta)^2}{\sigma_v^2+\sigma^2}\right\}}{\sqrt{2\pi}(\sigma_v^2+\sigma^2)^{1/2}[\phi(z_u\delta/\sigma)\phi(\mu_u^0+\sigma_0)]} \tag{7}$$

That is $\mu_{*_{it}} = [\sigma_v^2 z_{it}\delta + \sigma^2(c_{it} - X_{it}\beta)]/(\sigma_v^2 + \sigma^2)$ and the log of the function likelihood for observations, in terms of parameters $\sigma^2_s \equiv \sigma^2_u+\sigma^2_v, \gamma\equiv \sigma^2_u/\sigma^2_v$ and $\theta = (\beta' \;\; \delta' \;\; \sigma_v^2 \;\; \sigma^2)'$ will be

$$L^0(\theta;c) = -\frac{1}{2}\left(\sum_{i=1}^{N} T_i\right)\left\{In\,2\pi + In\,\sigma^2\right\} - \frac{1}{2}\sum_{i=1}^{N}\sum_{i=1}^{T_i}\left[(c_u - X_u\beta - z_u\delta)^2/\sigma^2\right]$$
$$-\sum_{i=1}^{N}\sum_{i=1}^{T_i}\left\{In\phi\left[\frac{z_u\delta}{(\gamma\sigma^2)^{1/2}}\right] - In\phi\left[\frac{1}{\sigma}\left(\left(\frac{1-\gamma}{\gamma}\right)^{1/2} z_u\delta + \left(\frac{1-\gamma}{\gamma}\right)^{1/2}(c_u - X_u\beta\right)\right]\right\} \quad (8)$$

For maximizing the log of the likelihood function (8) the first derivation of the function should be estimated and equated to zero. But in this case, the first derivative is nonlinear and therefore cannot be solved. So by using repetitive optimization, it should be maximized. for this purpose, starting points of unknown parameters are selected and it will be continued until convergence at Maximum likelihood estimation (MLE). MLE method for a specific group of data is defining some amounts for model parameters that the results will be the highest probability for data (i.e. parts of parameters that maximize the likelihood function). In this study Stata 15; software was used to estimate the parameters.

1-Data

The data are collected from manufacturing firms for this purpose the firms were categorized based on industry, and then 105 firms were selected randomly from each category as the sample. The period of the research is ten years (2008-2017). required data are collected Financial Statements were extracted from Codal website and Rahavardnovin database. Due to the structural differences of industries and to consider its effect, model estimation is performed for each specific industry separately. So, similar industries were combined and industries with fewer active firms were categorized as other industries.

2-model

After reviewing the literature and regarding Iran's condition, Trans log function was selected. This function was introduced by Christensen et al in 1972 which indicates the highest production obtained by combining production factors. Trans log is a non-linear function. To simplify the estimation and analysis a log form based on model 9 is used.

$$lnQ = ln\alpha_i + \sum_{i=1}^{n}\beta_i\, lnx_i + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\gamma_{ij} lnx_i lnx_j + \frac{1}{2}\sum_{i=1}^{n}\gamma_{ii}(lnx_i)^2 \quad (9)$$

In the literature of stochastic frontier production, there are two theories. In the first one, it is supposed that technology construction is fixed over time and no technological change occurred. In the second approach, which continues to the present study, it is assumed that the technology structure changes over time. Before Green's (2005) model, stochastic function the intercept is considered fixed for all firms. Green, by using intercept specification argued that the intercept is not fixed and it may change as fixed or random effects. According to the explanations, Green's model is used in this study.

For measuring efficiency, all factors affecting operational revenue, based on their type and Its function in production, should be included in the model, so the model:

$$\begin{aligned} lnsale=&\beta_0+\beta_1\, lndm_{it}+\beta_2\, lnwage_{it}+\beta_3\, lnoht_{it}+\beta_4\, lnsg\&at_{it}+\tfrac{1}{2}\beta_5 \\ &(lndm_{it})^2+\tfrac{1}{2}\beta_6\,(lnwage_{it})^2+\tfrac{1}{2}\,\beta_7(lnoht_{it})^2+\tfrac{1}{2}\beta_8\,(lnsg\&at_{it})^2 \\ &+\beta_9\, lndm_{it}*\, lnwage_{it}+\beta_{10}\, lndm_{it}*lnoht_{it} \\ &+\beta_{11}lndm_{it}*lnsg\&at_{it}+\beta_{12}\, lnwage_{it}*lnoht_{it} \\ &+\beta_{13}lnwage_{it}*lnsg\&at_{it}+\beta_{14}lnoht_{it}*lnsg\&at_{it}+v_{it}-u_{it}+¥_{it} \end{aligned} \quad (10)$$

Defining variables

lnsale: natural log of sales during the period.

Indm: natural log of direct materials

Inwage: natural log of Wages, (Wages of all production, sale and office staff)

Invot: natural log of other costs of the production sector, (production overhead except for indirect wages)

Insg & at the natural log of other expenses of sale and office section (total amount of sale and office expenses except staff Wages)

u_{it}: some of the residuals which indicate inefficiency.

v_{it}: some part of the residuals which indicates a random error.

($¥_{it}$) eta: the effect of technology changes over the period.

Results and conclusions

For the purpose of data analysis, descriptive statistics of the research variables are shown in Table 1. The table includes information on median, mean, and other statistical information related to research variables.

Table 1. Descriptive statistics

variables	lnsale	lndm	lnwage	lnoht	lnsg&at
Ave.	13.64	12.689	11.763	11.93	10.154
Mid	13.52	12.592	11.598	11.82	9.949
max	19.729	19.673	16.86	18.52	16.322
min	10.112	0	8.503	6.078	5.897
S.D	1.603	1.943	1.319	1.797	1.657
Skewness	0.832	0.188	0.948	0.546	0.741
Kurtosis	4.203	8.23	4.532	4.034	3.657
N	1050	1050	1050	1050	1050

Stochastic frontier production function shows the maximum production of active firms in an industry. In this model for function fitting, frontier points are selected. So, in comparison to economic models which average points are selected, it is advantageous to play a greater role in determining frontier lines so that it causes a reduction in errors of ordering least squares (OLS) which gives remote observations the same priority. The model estimation results are presented in Tables 2 for any industry.

Table 2. The efficiency of different industries

Industry	Average industry efficiency	min		max	
		efficiency	firm name	efficiency	firm name
Chemical	62%	40%	Dode Sanati Pars	96%	Palayesh Naft Isfahan
Food	77%	62%	Shahd Iran	94%	Santa behshahr
Cement	90%	84%	Cement Khazar	95%	Urmia Cement
Medicine	82%	61%	Darosazi Aksir	98%	Alborz Daro
Car and Parts	65%	52%	Ahangari Taraktorsazi	92%	Irankhodro
Machine	75%	75%	Kombinsazi	98%	Sanati Botan
Mineral	53%	39%	Shishe Qazvin	95%	Khak Chini Iran
Metals	55%	42%	Alomtak	90%	Melli Sanati Mes Iran
others	95%	70%	Plastiran	99%	Motozhen

According to the results shown in Table 2. mineral industries, an average of 53 per cent and cement industry with an average of 90 per cent had the lowest and the highest efficiency respectively.

In table 3 and 4, the results of the model and separating the residuals is shown. For all industries, the model was first conducted for random effects. If

($¥_{it}$) eta is significant, it is an indicator of changes in technology and efficiency during the period of research.

Table 3. Maximum likelihood estimation model results

Industry	Chemical		Food and sugar		Cement		Medicine	
Variables	Coefficient	P>|z|	Coefficient	P>|z|	Coefficient	P>|z|	Coefficient	P>|z|
lndm	-0.096	0.596	0.386	0.037	-0.783	0.038	-0.427	0.406
lnwage	1.682	0	0.565	0.041	0.843	0.044	0.813	0.299
lndm2	0.053	0	0.122	0	-0.093	0.562	0.251	0
lnwage2	-0.114	0.012	-0.06	0.5	-0.115	0.026	0.027	0.905
Lndm*lnwag	0.084	0.001	0.009	0.754	0.062	0.704	-0.124	0.019
lnsgat	-0.461	0.044	-0.076	0.68	0.337	0.568	0.319	0.699
lnoht	0.569	0.048	0.542	0.001	-0.283	0.665	0.368	0.209
lnsgat2	0.109	0.01	0.01	0.564	-0.07	0.023	-0.125	0.506
lnoht2	0.019	0.634	0.139	0	-0.051	0.563	0.068	0.008
Lndm*lnsgat	-0.116	0	-0.041	0.038	-0.173	0.025	-0.017	0.895
Lnwage*lnsgat	0	0.234	0.068	0.025	0.154	0.042	0.109	0.553
Lnsgat*lnoht	0.075	0.047	-0.017	0.277	0.041	0.443	-0.009	0.838
Lndm*lnoht	-0.003	0.743	-0.093	0	0.235	0.028	-0.049	0.028
Lnwage*lnoht	-0.101	0.041	-0.048	0.033	-0.134	0.018	-0.022	0.648
_cons	-1.791	0.316	-0.858	0.456	8.764	0.357	1.102	0.7
($¥_{it}$)eta	*		*		*		-0.071	0.011
sigma2	0.495		0.004		0.013		0.058	
gamma	0.952		0.336		0.382		0.889	
sigma_u2	0.472		0.004		0.002		0.052	

sigma_v2	0.024	0.001	0.01	0.007
log likelihood	39.485	139.115	73.388	93.312

Table 4. Maximum likelihood estimation model results

Industry	car and parts		Machine		Mineral and tile		Metals		others	
	Coeffi	P>|z|	Coeffi	P>|z|	Coeffi	P>|z|	Coeffi	P>|z|	Coeffi	P>|z|
Lndm	0.39	0.04	0.88	0	0.16	0.76	0.39	0.03	1.16	0
lnwage	0.2	0.38	0.51	0.03	0.85	0.04	1.11	0	0.59	0.02
lndm2	0.03	0.69	-0.05	0.01	0.26	0	0.15	0	0.16	0
lnwage2	-0.06	0.05	0.02	0.77	-0.02	0.85	0.04	0.49	0.08	0.03
Lndm*lnwage	0.03	0.51	-0.04	0.29	-0.01	0.92	-0.08	0.04	-0.14	0
lnsgat	0.19	0.05	-0.37	0.03	-0.16	0.77	-0.11	0.65	-0.66	0
lnoht	0.27	0.02	0.46	0.01	1.19	0	0.32	0.03	0.05	0.53
lnsgat2	-0.02	0.5	-0.14	0	0.09	0.03	-0.03	0.59	0	1
lnoht2	0.1	0	0.08	0	0.08	0.05	0.1	0	0.09	0
Lndm*lnsgat	0	0.99	0.17	0	-0.07	0.04	-0.02	0.6	0	0.87
Lnwage*lnsgat	0.04	0.04	-0.02	0.55	-0.02	0.75	0.03	0.5	0.05	0.05
Lnsgat*lnoht	-0.03	0.02	-0.01	0.61	0.04	0.33	0.03	0.33	0.01	0.33
Lndm*lnoht	-0.05	0.01	-0.08	0	-0.18	0	-0.07	0	-0.08	0
Lnwage*lnoht	-0.02	0.31	0	0.89	-0.01	0.75	-0.05	0.05	0	0.68
_cons	52.11	0	-1.63	0.27	-4.45	0.05	198.32	0	-0.82	0.42
($¥_{it}$)eta	-0.0002	0	0.09	0.01	-0.02	0.03	-0.0001	0.04	-0.09	0.02
sigma2	0.0067		0.024		0.0682		0.0458		1.3378	

gamma	0.4025	0.6924	0.8904	0.6215	0.9835
sigma_u2	0.0027	0.0166	0.0607	0.0285	1.3265
sigma_v2	0.004	0.0074	0.0075	0.0173	0.0113
log likelihood	123.93	94.34	89.94	69.83	121.19

As shown in table 3 and 4 For chemical, food, and cement industries, estimated (¥$_{it}$) eta is not significant, in other words, the technology has not changed during the study. Regarding the coefficient of (¥) eta for machinery industries efficiency is increasing. Results are in conformity with those reported by Sharma et al (2007), Diewert (2008), Huang et al (2009), Pe´rez-Reyes and Tovar (2009). And for other industries with significant values, the efficiency has dropped. Results are in line with those reported by Piesse and Thirtle (2000), Deliktas et al (2001), Giovannini and Nezu (2001).

Gamma is another important statistics of the model. The gamma is obtained by dividing variance of u (sigma-u2) by the total variance (sigma2) and it shows the effect of firms controlled factors on inefficiency. Gamma was 33.6 per cent for the food industry and it shows that it is a result of the total residuals (inefficiency) 33.6 per cent of firm controlled factors and by 66.4 per cent affected by environmental factors (out of firms control). Gamma was the highest (95.2 per cent) for chemical industries (inefficiency affected by firms controlled factors) and by 1.65 per cent inefficiency (environmental factors). For each industry, gamma is shown in Table 3.

Suggestions

As it was described in the previous parts, the advantage of scholastic frontier function to other methods is separating inefficiency into firm-controlled factors and environmental factors. So assessing the efficiency of a firm should be based on controlled parts. Managers are advised to, after determining inefficiency caused by controlled factors, identify the causes and attempt to tackle the barriers and increase the efficiency.

Investors are also advised to be careful in selecting, evaluating and rating efficiency concerning separating inefficiency. As a factor of operating auditing, there is no model for assessing efficiency. Utilising the model represented in this study is advised for auditors. Based on the previous studies the effect of uncontrollable factors is greater than controlled factors on inefficiency. Therefore, it is suggested that regulators identify major factors affecting the inefficiency of industries and try to reform the laws if needed.

In some accounting models, the residuals are used as the criteria for assessing a specific variable in the literature (for example management ability, information asymmetry and earnings management). Instead of the ordinary regression function, the model frontier function is suggested. By separating controlled and uncontrollable factors the precision of the results will be increased and the results would be more reliable.

Research variables were sales and expenses of the financial period. Depreciation expense is calculated based on historical cost but other research variables are reflected in the current cost. Given the severe inflation in some periods of research that causes a discrepancy between historical and current prices, so inflation is an important limitation of the study.

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