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Measuring Productivity of Private Companies on the Iran Stock Exchange

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Abstract
Through the calculation and analysis of the productivity indices of the total production elements, it is possible to determine the performance of the private industrial sectors in terms of the optimized application of the production resources. Therefore, these days, productivity is considered necessary for the economic growth and improvement of lifestyle and welfare of a country. Our country's success depends on technical know-how, creativity of the employees, applying new scientific methods for management and innovation, all of which will be manifested in form of an increased productivity.
We can determine the performance of private sectors for optimising production resources through analysis and calculation of index factor from factor productivity.
The purpose of this study is to measure the productivity of companies and selected industries on the Tehran Stock Exchange. This research measures total, average and final productivity of various industrial activities over the period 2001–2009. To study and evaluate total productivity of the industries, a Cobb–Douglas production function is used. The results indicate that the overall productivity is 2.12. In fact, the per unit cost to income ratio of the private firms increases, productivity increases 2.12 units; final productivity of capital, labour force and intermediate goods are 0.60, 4.94 and 0.51, respectively.
Key words: performance measurement,productivity measurement , total factor productivity (TFP), Cobb–Douglas function,.

1. Introduction

The strategic importance of productivity for any company or organization implies the need to exercise control over it. By measuring productivity, a company develops an explicit link between productivity and other strategic objectives. Apart from its strategic advantages, measuring productivity is helpful in other supporting functions.
Productivity in industrial production is one of the major criteria through which we can evaluate the power of an industrial activity to achieve its relative advantages at domestic and international levels. In other words, productivity growth is one of the principal requirements for improving competitiveness in industry, and for driving success in the increasingly competitive global business environment. The reason for this is that productivity growth reduces a product's total cost of sales by reducing average production costs; this leads to increased profit from the final products.
Besides limited resources, one of the often-neglected principal challenges and problems of developing countries is low productivity. Serious attention should be paid to this problem.
Nowadays, improving productivity is considered an important strategy to improve the economic, social and cultural development of a nation. Success in accelerating productivity improvement is one of the main ways to achieve an advantageous position in the global marketplace, and to increase people's prosperity.
Company performance can be assessed in two different ways. One is to take company productivity into account; the other is to evaluate companies on the basis of their annual accounting reports, as extracted from company financial information (Kitaeva 2003).
Productivity can be measured in terms of technical efficiency and effectiveness. By technical efficiency, we mean the conversion of inputs to outputs in the course of normal operations. Effectiveness in the strategic area refers to the degree to which an organization's objectives can be reached based on its output (Rouse, Putterill and Ryan 1997).
Improving productivity is normally a primary responsibility of management. Increasing productivity is not possible without analysing it. Measuring productivity in private companies helps us to identify effective factors that can be used to improve productivity in general. According to the experiences gained in industrial countries, implementation

of a proper productivity evaluation system, even without making any modification, can increase productivity by 5% to 10% (Mahboubi 2003).

The present study aims to measure productivity of private companies on the Tehran Stock Exchange. First, a review of the literature will be presented. Then, concepts, methods and measurement models of total factor productivity (TFP) will be presented according to the methodological framework of the research. The following section presents the calculation of a production function for five industries using data from the period 2001–2009. The next section covers final productivity, labour force and intermediate goods. The last section presents the discussion and conclusion.

2. Literature review

Solow (1957) pioneered in developing and applying a preliminary approach to analyse productivity growth by using partial factor productivity. This indicator of productivity is measured by the ratio of total production factors of the product to one of the inputs. However, this method is not applicable in determining the role of factors that can affect productivity growth. To eliminate this deficit, Jorgenson et al. (1987) divided factors affecting the production growth rate into two parts. The first part is about the role of the growth rate of inputs, and the second part is about the impact of residual terms on TFP. On the basis of this method, TFP is calculated as the discrepancy between the growth rate of a product and the weighted average growth of inputs (the share of inputs in the gross value of the product in each part).

A review of the studies in different countries shows that most of the recent studies in TFP and factors affecting it are based on the Jorgenson Gollop model, where they presented a model for analyzing the total productivity growth against its sources for individual industries. The productivity growth for every industry was obtained from the proportion of gross product of every sector to the total GDP.

These include studies conducted by Abimanyu and Xie (1994) and Tham (1994). The results of these studies indicate that capital accumulation is one of the principal factors affecting the growth and development of an industry. According to the above-mentioned subjects, the following studies are presented.

Liao et al. (2010) investigated changes in productivity of securities firms in Taiwan. They used the Malmquist index to measure the productivity change of Taiwanese securities firms over the period of 1992–2007, and compared the productivity changes in stages: the pre-Asian financial crisis period, the post-Asian financial crisis period to the period of financial reform, and the post-financial reform period. Finally, a series of analyses was applied to specify efficiency indicators. They discovered that while securities firms registered positive productivity growth in Taiwan, the Asian financial crisis affected both the efficiency and earnings of the securities industry as well the Exchange industry. Their findings indicate that the effects of outdoor monitoring mechanisms are more prominent than indoor ones.

Lin (2010) explored efficiency, productivity change and corporate value during the financial crisis. Using data from Asia banks, this study reviewed efficiency in the banking industry using the Malmquist index to measure the relative efficiency of the banking industry in nine Eastern Asian countries from 1993 to 2002. The empirical results showed that after the Asian financial crisis (1998–2002), technical efficiency dwindled in Indonesia, Malaysia and Thailand.

This study conducted structural analysis and comparison of changes in the productivity of banks in nine Eastern Asia countries to ascertain the correlation of productivity changes with the corporate value. Changes in scale efficiency and net efficiency were the important factors affecting company valuation after the Asian financial crisis in 1998–2002; these factors turned out to have a significant role in investments made within the banking market.

Yilmazkuday (2009) studied the productivity cycles of public and private manufacturing sectors in Turkey by using a regime shifting model applied through the multi-move Gibbs-sampling approach over the quarterly period 1988–2006. By considering business cycle time for the sample period, the study determined that the public sector had higher productivity growth rates compared with the private sector, and that both systems contained high and low productivity growth regimes.

Fernandes (2008) studied firms' productivity in Bangladesh manufacturing industries by analysing the relationship between productivity and TFP for firms in Bangladesh. By controlling for industry, circumstances and constant annual effect, she found that firm size and TFP are inversely related to each other, while the age of a firm and its TFP have a reverse U-like relationship.

Her findings also revealed that factors such as problems with financing, elaborate administrative systems and violations could make productivity by decreasing TFP.

Halkos and Tzeremes (2007) studied the relationship between company size and productivity performance; they claim productivity levels may correlate with the size of the firm, as measured by the number of employees. In general, smaller companies organized production processes differently than larger companies. An increase in firm size is, initially, expected to have a positive effect on productivity levels because of economies of scale (and scope).

However, when a firm grows beyond a certain size, *diseconomies* of scale may have a dominating effect, thereby negatively influencing productivity levels.

Margono and Subhash (2006) studied and analysed efficiency and productivity in Indonesian manufacturing industries. This study investigated technical efficiency and productivity growth by TFP in food, textile, chemical and metal industries in Indonesia using the stochastic frontier model during the period 1993–2000. Estimation of productivity growth by TFP revealed that productivity in Indonesian manufacturing industries decreased by 2.73%, 0.26% and 0.5% for food, textile and metal industries, respectively. However, in chemical industries it increased by 0.5% during the period under investigation. The decomposition of TFP growth indicates that the growths are driven positively by technical efficiency changes and negatively by technological progress in all four sectors**.**

Haltiwanger et al. (1999) studied the differences in productivity among workers in different industries during the period 1985–1996 by using the production function. They concluded that the number of workers, age and human capital affect the rate of productivity.

Idson and Walter (1999) also used the production function approach to study and compare work force productivity within small and large industries such as fabricated metals, machinery, electrical equipment and transport equipment. They concluded that a large industrial labour force improved productivity in large industriesvia the use of technology, equipment and organization as compared with small industries.

Pilat (1995) compared the productivity of various industries in South Korea with similar industries in America and Europe. He found that although productivity in some Korean industries such as leather, metals and machinery was comparable to that of their European counterparts, the overall productivity of Korean industries was about 26% that of American industries. In his view, factors such as the use of capital, savings resulting from industrial-scale production, and workforce education are the most important factors causing this difference in productivity between American and South Korean industries.

3. Research method and data collection

This research has a practical purpose and is a descriptive retrospective study conducted over a period from 2001 to 2009. The statistical population of this study includes industries known as profitable on the basis of previous studies. Additional requirements were that the companies' data were available during the course of the study and that their stocks were active. Thus, 19 companies from 5 industries were selected.

To collect data for this study, time series values of employment and capital stock statistics of 5 industries were extracted from basic financial statements reported between 2001 and 2009. For measuring partial productivity of capital, final productivity of capital was used as the ratio of changes in added value to capital changes. Since the ratio of output to input for measuring TFP cannot represent a suitable estimate of its real amount, the production function technique was used to measure TFP, and ordinary least squares (OLS) was used to estimate introduced functions.

Table 1 Statistical population of this study

Number	Type of industry	Private company
1	All kinds of food products and beverages	3
2	Chemical materials and products	3
3	Pharmaceutical materials and products	4
4	Other non-metallic mineral products	4
5	Machinery and equipment	5
Total		19

3.1 Introduction to the model

To estimate and evaluate TFP, production functions were used. To estimate private companies' production functions, OLS and LS techniques were used because OLS is the best known and widely used method; its estimations are non-biased, compatible and efficient.

$Q = AK^{\alpha}L^{\beta}z^{J}$

$Q = F(L, K, Z)$.

Q: Total production, A: Total productivity parameter, K: Capital stock, L: Labour, Z: Intermediate goods, α: Investment's produced coefficient of elasticity, β: Labour productivity's coefficient of elasticity, J: Production elasticity coefficient of intermediate goods

$log\ (Q_{it}) = \log(A) + \alpha\log({}_{i}K_{it}) + \beta\log(L_{it}) + J\log(Zi_{i}t) + {}_{t}\varepsilon_{it}$

$log\ (Q_{it}) = \log(A) + \alpha\log({}_{i}K_{it}) + \beta\log(L_{it}) + J\log(Zi_{i}t) + \varepsilon_{it}$

Here the indexes i and t represent i^{th} company and the time. The mentioned production function was estimated for a selected group of private companies by using a Panel data approach and Eviews7® software. In general, TFP is the ratio of output (real added value) to average weight of inputs. This reflects the share of each input in total production cost, and is calculated using a modified Kendrick index as follows:

$$\text{TFP} = \frac{AV}{\alpha K + \beta L + jZ}$$

where TFP is the total factor production, AV is added value, L is labour force, K is capital and Z is intermediate goods. Therefore, TFP expresses exogenous technical progress in a production model. It is about how production changes with time when production inputs (work and capital) are fixed.

$$MP_{ij} = \frac{\Delta VAj}{\Delta Fij}$$

If this ratio is expressed as the changes of output to changes of one input, it is called final productivity of a factor. In the above function, MP_{ij} is the final productivity of the factor i (labour force and capital) in department j, $_j VA\Delta$ is the changes in added value of department j and $_{ij}F\Delta$ is the changes in input of factor i (labour force and capital) in department j.

Likewise, efficiency is defined by dividing a weighted combination of output by that of input. The weights are actually the produced value or spent cost.

The production function was estimated for a group of selected private companies by using a Panel data approach and the Eviews7® software. The estimation results are displayed and discussed next.

$$\boxed{\text{Efficiency} = \text{total outputs/total inputs}}$$

4. Research findings

4.1 Tests conducted to determine the validity and fitness of the estimation model

4.1.1 Hausman test

The Hausman test is used to compare fixed and random effects' models in terms of explaining the power of the dependent variable. As a result, to compare these two models, the correlation between random effects (αi) and the regression should be tested. If the calculated statistic is higher than the value in the table, H0 is rejected and a correlation exists; therefore, the random effects method should be used.

H0: There is no correlation between random effects and regression.

H1: There is a correlation between random effects and regression.

Hausman test:			
F-statistic	0.76	Probability	0.67

In this test, because the p-value is 0.01 and the calculated test statistic is higher than the value in the table, the null hypothesis is rejected and fixed effects are used in the estimation.

4.1.2 Heteroskedasticity and White test

One of the major problems in the regression model is estimated heteroscedasticity of error terms. Such a problem in the regression will cause the results of the OLS method not to be the most efficient anymore. In other words, $E(U_i^2) = \theta^2$, (i = 1, 2, 3, …, n). The violation in this hypothesis causes a problem called variance similarity.

The variance of error terms is equal to the variance of the dependent variable, and the heteroscedasticity problem is related to dissimilarity of the dependent variable variance at different points of time. The White test is used to find heteroscedasticity in the model.

H_0: There is no variance similarity.

H_1: There is variance similarity.

The White Test for heteroskedasticity:			
F-statistic	3.275	Probability	0.0045
Obs*R-squared	18.29	Probability	0.0055

Based on the White test, because F = 3.275 and probability = 0.0045, H0 is rejected and H1 is accepted.

4.1.3 Autocorrelation and LM test

The other classical assumption, based on OLS estimation is non-existence of a relationship between remainder at different points of time. [Remark 8] In other words, $E(U_i U_j) = 0$. The violation of the hypothesis creates a problem called autocorrelation. To find whether autocorrelation exists, an LM test is used. Because the data used in this study are annual, if a factor such as recession affects the total production during a year, there is no reason to believe that such trends would continue in later years. If there is such dependence, it indicates autocorrelation, and makes it necessary to use an LM test. If there is an autocorrelation between the independent variables, it can be solved via econometric solutions.

H_0: Autocorrelation

H_1: Lack of autocorrelation

Breusch–Godfrey serial correlation LM test:			
F-statistic	64.37	Probability	0.0000
Obs*R-squared	47.71	Probability	0.0000

Based on the LM Test, because F = 64.37 and probability = 0.000, H0 is rejected and H1 is accepted.

4.1.4 Omitted variable test

We use this test to examine whether the independent variable is effective on the dependent variable. In other words, will this variable really affect the dependent variable that we enter into the estimation model? For example, one of the independent variables, intermediate goods factor (which affects the total production), is added to the initial estimation model and will be estimated by this test.

H_0: Intermediate goods input has no significant effect on total production.

H_1: Intermediate goods input has a significant effect on total production.

Omitted variables: LOG (Z)			
F-statistic	582.92	Probability	0.0000
Log likelihood ratio	256.93	Probability	0.0000

Based on the omitted variable test, because F = 582.92 and probability = 0.000, H0 is rejected and H1 is accepted. Therefore, the variable will enter the initial estimation model.

4.1.5 Cointegration test

Engle-Granger (1987) stated that if a Dickey–Fuller test is conducted on the residues of the model, the time series of residues is stagnant, then it is a proof of cointegration, and there is a long-term relationship between the dependent and independent variables in the estimated model. Therefore, we conduct the same test.

H_0: Cointegration

H_1: Lack of Cointegration

Augmented Dickey–Fuller unit root test on LN (T.tax)			
ADF test statistic	−6.515	5% critical value	−1.952

Because ADF = 6.515 and the minimum accepted H0 at 5% level is −1.952, and the Dickey–Fuller statistic is higher than the critical rate, H1 is rejected and H0 is accepted, thus indicating cointegration. In other words, there is a long-term equilibrium relationship between independent and dependent variables in the estimated model.

4.2 Estimated production functions for private firms

Table 2 shows the results of production function estimation for selected private companies.

Table 2 Production function estimation results for private companies

Variable	Coefficient	Prob
Intercept	−1.82	0.04
Capital stock	0.28	0.0
Work force number	0.38	0.0
The amount of intermediate goods	0.40	0.0
R^2	0.97	
F-Statistic	223.	0.0
Durbin–Watson stat	2.06	

The estimated production function can thus be written as follows:

$\text{Log}(Q) = -1.82 + 0.28\ \text{Log}(K) + 0.38\ \text{Log}(L) + 0.40\ \text{Log}(Z) + \varepsilon$

T3 = 2.892 T1 = −5.422

T4 = 4.386 T2 = 2.187

$R^2 = 0.97$ F = 223 DW = 2.06 $\overline{R^2} = 0.95$

In the estimated function, all variables that were expected to be influential on the dependent variable are in the estimated model due to the significant coefficients and tests, and were selected as the best model.

From the estimated regression, all parameter coefficients are significant (T1 to T4 are all above two); hence, the current regression is reliable.

Based on R^2 and $\overline{R^2}$ models with 95% probability (5% error level), the rate of correlation between the dependent variable (total production) and the independent variables is 97%. As a result, on the basis of the coefficient of determination, 97% of the changes in the dependent variable (total production) are due to the changes in independent variables and the remaining 3% are related to other factors. As a result, as we mentioned earlier, the model is able to show necessary credit.

Interpretation of estimated private companies' production function:

Final productivity of capital, labour force and intermediate goods in selected private companies are shown in Table 3 obtained using the following formulae:

Final productivity of capital: $Mp_k = \frac{\partial Q}{\partial K} = \alpha\, Ak^{\alpha-1}L^{b} = \boldsymbol{\alpha}\frac{Q}{K}$

Final productivity of labour force: $\mathbf{MP_L} = \frac{\partial Q}{\partial L} = \boldsymbol{\beta} \mathbf{KA}^{\alpha}\mathbf{L}^{\beta-1} = \boldsymbol{\beta}\frac{Q}{L}$

Final productivity on intermediate goods: $MP_Z = \frac{\partial Q}{\partial Z} = JAZ^{J-1}K^{\alpha}L^{\beta} = J\frac{Q}{Z}$

Table 3 Estimation results of final productivity of capital, labour and intermediate goods function for private companies

	Private company
Final productivity of capital	$MP_K = (0.28) \times (2.14) = 0.60$
Final productivity of labour force	$MP_L = (0.38) \times (13) = 4.94$
Final productivity on intermediate goods	$MP_Z = (0.40) \times (1.275) = 0.51$

A) The final productivity of capital in private companies is 0.60. That is, a one-unit increase in the companies' capital corresponds to an increase of 0.60.

B) The final productivity of labour force in private companies is 4.94. That is, a one-unit increase in companies' labour force corresponds to an increase of 4.94.

C) The final productivity of intermediate goods in private companies is 0.51. That is, a one-unit increase in private companies' intermediate goods consumption corresponds to an increase of 0.51.

4.2.1 Calculation of the average productivity of production factors in selected private companies

Average productivity is the average produced goods per unit of desired input; in other words, the average share of inputs is shown in the total production.

A) The average productivity of capital in private companies is equal to 2.14.

B) The average labour productivity in private companies is equal to 13.

D) The average productivity of intermediate goods in private companies is equal to 1.275.

4.2.2 Calculation of the total productivity in private companies

To calculate the total productivity, the share of each of the production factors of total costs is calculated and selected as an index. The total productivity is calculated using the following equation. After estimating the total productivity of the private companies, 2.12 units were obtained as shown in Table 4.

Table 4 Results of estimated total productivity for private companies

Total productivity calculation Private companies	$TFP = \dfrac{AV}{\alpha K + \beta L + jZ} = 2.12$

4.2.3 Calculation of pull production for private companies

The pull production of each factor is computed by dividing the final production by the average production of the desired inputs, that is, Mp/Ap. In the estimated function of the Cobb–Douglas function, the pull production of each production factor is the same as input coefficients. Hence, the production elasticity of each of the inputs used in private companies is as follows**:**

	Capital	Labour Force	Intermediate goods	E = Mp/Ap
Final Productivity	0.60	4.94	0.51	0.28
Average Productivity	2.14	13	1.275	0.38
Elasticity of Factors	0.28	0.38	0.40	0.40
Production Zone	Second economic region	Second economic region	Second economic region	

As can be seen, the elasticities of capital producing factor, labour force producing factor and intermediate goods producing factor are all positive and less than one. It can be concluded that private manufacturing companies are active in the economic production region (the second economic region). It is notable that if the pull factors approach zero, these companies approach the border of the second and third regions, where production lies at its best situation**.**

5. Conclusion

In this study, following the review of literature on productivity factors, we have attempted to discuss different methods and approaches to calculate and measure total and partial productivity of private industries. Using the introduced methods, an indicator of total productivity was measured in five large private industries on the Tehran Stock Exchange. With regard to partial productivity of production factors, labour force productivity was measured using an indicator of average productivity of the labour force; capital and intermediate goods productivity was measured using indicators of partial productivity (both average and final productivity); capital productivity was measured by an indicator of final productivity for private companies on the Tehran Stock Exchange.

Furthermore, to measure TFP, tests and models that estimated a more realistic model were used. Therefore, based on the results of this calculation, TFP values were calculated to be 2.12 in private companies. This implies that each addition of a one-unit cost to income will increase production values of 2.12 in private companies. In other words, increasing all factors of production by one unit will increase production values by 2.12.

The optimal allocation of inputs in Iran's private companies is derived from VMP = P. In other words, the optimal allocation of inputs occurs when the final value of production equals input values. The results are presented as follows.

A. Optimal allocation of capital inputs

Based on the final value of capital inputs to production and the value of produced goods in private companies, we get V MPK < P. That is, capital consumption in private companies is much greater than it would be at an optimized level. It therefore can be reduced, leading to optimized production. In this regard and by using the production function method, Haltiwanger concluded that factors such as size of the labour force, age and human resources affect the productivity rates of a company.

Likewise, Pilat concluded that during the study period in Korea, some industries such as leather, metals and machinery equalled productivity levels of European industries, but the total productivity in Korean industries was about 26% of American industries in 1987. The most important effective factors in Korean industries' productivity were excessive use of capital, savings because of the production scale of the industries and the educational level of the labour force.

B. Optimal allocation of labour force inputs

Based on the final value of labour force inputs and the value of produced goods in private companies, we get VMPL > P. That is, the employment of workers in private companies is less than at an optimized rate. Therefore, the employment of the labour force can be increased, leading to increase in employment and more effective production.

C. Optimal allocation of intermediate goods inputs

According to the final value of intermediate goods inputs and the value of produced goods in private companies, we get VMPZ < P. That is, the consumption of intermediate goods in private companies is higher than optimum. Therefore, consumption of this input should be reduced, leading to the optimal use of resources in this section.

The results show a fairly appropriate condition for factor productivity in selected industries. Therefore, coordinated support of productivity in selected industries requires serious attention for improving productivity in departments, and deserves to be prioritized in productivity improvement programs. Productivity improvement policies should be implemented so that productivity of production factors (labour force, capital and intermediate goods) improves harmoniously in order to prevent productivity deterioration in industry.

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