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Estimation of production function and labor productivity rate in Aghajari Oil and Gas Production Company

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Abstract

Considering the importance of oil in national income and gross national product, the estimation of oil production function is of particular importance. In this regard, Karoon Oil and Gas Production Company as the largest oil and gas production company in Iran was selected as the research subject and its production function has been estimated during the period 1989-2011. For this purpose, the reliability of the study variables was examined by Dickey - Fuller Augmented test. Then, the error correction model was estimated using Engel-Granger cointegration. The results showed that the function is in the form of Cobb - Douglas during the study period. The elasticity of labor force, capital and energy are 0.398, 0.182 and 0.589, respectively. The Wald test result indicates that there is increasing return to scale.

Keywords: productivity, production function, oil and gas, cointegration, Granger-Engle.

Introduction

Given that oil industry plays an important role in Gross domestic production, sources of foreign exchange and share of oil revenues in the state budget, Aghajari Oil and Gas Production Company was selected as the subject of the research, because it produces about 20 percent of Iran's oil and also is considered as one of the subsidiary companies of National Iranian South Oil Company with a production capacity of more than 615,000 barrels per day.

Today, achieving economic growth through increased productivity and production is among the most important economic goals of the organizations, so that the close relation between social welfare and economic growth has made managers and planners seeking a better understanding of economic growth sources. The promotion of productivity with efficient use of production factors opens up new horizons in achieving sustainable development, and thus it must be accepted that serious attention to the issue of productivity, knowledge and the effect of production factors might allow achieving the economic growth rate stipulated in the fourth development plan. As stated in Section V of the Fourth Development Plan: Since the human resources reduction policies and increasing educated people have a significant effect on productivity, the calculation of production function and estimation of the labor productivity rate is a good guide for future policies of managers.

The main objective of this paper is to estimate the elasticity of production factors and the rate of labor productivity in Aghajari Oil and Gas Production Company. First we will mention the theoretical foundations and some of the similar research already done in this field. Then, in the section of methodology and empirical results, the relationships between various factors of oil and gas production are examined and interpreted using the estimated production function. In addition, the impact of each input on production, the production sensitivity to each of the production factors and the return to scale ratio are investigated. Finally, the overall conclusion of the present paper will be provided.

Theoretical Framework

The term productivity was first used in 1766 by Francois Quesnay, pro Physiocracy school (state of nature) mathematician and economist. Quesnay proposes the economic table plan and sees the authority of any government subject to the increased productivity in the agricultural sector. After more than a century, in 1883, someone named "Littre" defined productivity as the science and technology of production. With the inception of scientific management movement in the early 1900s, "Frederick W.Taylor" and "Frank and Lillian Gilbreth" carried out some studies on labor division, improving methods and determining the standard time in order to increase labor efficiency. "Efficiency" is defined as a ratio of the actual work time to the predetermined standard time. New method of measuring the efficiency and productivity was expressed in 1957 by "Farrell" the famous economist. However, the measurement possibility was provided with the efforts of economists and operational research experts in 1977 using econometrics (SFA) and in 1978 using linear programming (OEA) methods.

Productivity is defined as the ratio of the production of goods and services, or sets of goods and services (output) to one or more inputs that affect the production of those goods and services. Organization for Economic Cooperation and Development defines productivity as the ratio of output (production) to one of (total) production factor. ILO defines productivity as follows: Different products are produced by integrating four main factors. These four factors include land, capital, labor and organization. The ratio of integrating these factors on products is a measure for productivity. Productivity is realized in society when all productive, social and service sectors are trying to use a proper productivity system where the legislator can usually pave the way for creating productivity. To improve productivity, first of all the factors affecting productivity should be identified.

There are many categories of factors affecting productivity made by specialists and experts, below we mention some of them:

- Nakayama divided the factors affecting productivity into short-term and long-term factors.
- International Labor Organization determines the factors affecting productivity in three categories: general factors (climate, geographic distribution of raw materials, etc.), organizational and technical factors (quality of materials, location and delivery of factory, etc.) and human factors (management and staff relationships, social and psychological conditions of work, etc.).
- One of the reports of productivity reviews by the Ministry of Labor in Japan has divided the factors affecting productivity into three categories: deployment of equipment and personnel, labor skill and quality of materials.
- Samanath accounts for some of the most important factors affecting productivity in the United States, including the amount of investment, the ratio of capital to work, research and development, capacity utilization, government regulations, factory and equipment lifetime, composition of labor, and so on.
- Souter Meister considers productivity as the center of a circle and the factors affecting productivity are classified in concentric circles according to their degree of importance.

Some other economists have classified the factors affecting productivity as follows:

- Technological changes
- The workforce capacity which is limited to the specific capabilities and capabilities of the worker.
- The amount of capital per unit of labor, which reflects the degree of concentration of capital or the volume of capital can be consumed by the unit of labor.

Prokopanko has provided the following classification of the factors affecting an organization’s productivity:

External factors

refer to the factors that influence the organization from outside which are not under the authority of managers within the organization. It means that the organizational management is not able to control or affect them in the short term. In the end, the organization must adapt itself to the changes they make. The external factors affecting an organization's productivity are divided into three groups: structural reform, natural resources, and infrastructures and state.

Internal factors

these factors are under the authority of individuals and managers within the organization and a proper management can use them with high efficiency. These factors can be divided into hardware and software. The hardware consists of four sections of production, plant and equipment, technology and materials and energy. The software factors include the four sections of people, organization and system, methods of work and management style. In general, the components of productivity improvement can be outlined as follows:

Employee participation, incentives, motivations, profit share, ownership measuring, monitoring, leadership, goals, communication, teamwork, collaboration, education, lifestyle, work environment, respect, growth potential, job design, job security, job satisfaction, positive motivation, planning, job independence, structure, character, education and development, commitment to quality, flexibility and motivation. From theoretical perspective, labor productivity growth is obtained from two sources: per capita capital growth and total-factor productivity improvement. Capital production techniques increase the labor productivity and improved total-factor production productivity increases the labor productivity. Improved total-factor production productivity can be the result of factors such as better management of production resources (including optimal resource allocation and better use of available resources and facilities), increased human capital (including improving the health levels, increasing the education level and skills of the workforce), increased motivation of the workforce for more and better work, creativity and innovation, reforming the age, gender, and job structure of the workforce and technology advancement. The user production techniques also increase capital productivity and improving total production factors will increase the capital productivity.

Research Background

Hadi Zenouz and Bakhtiari (2010), in their study, investigated the factors affecting the productivity of production factors in Carbon Iran Company during the period of 1999-2008 using the Cobb-Douglas production function method. In this function, the explanatory variables include: simple workforce, expert workforce, and capital and energy inventory, where their first-order changes in the production function estimation are used to eliminate the nonstationary data. The results show that the simple and expert workforce productivity, despite the severe fluctuations, has had relative growth. Energy productivity has grown considerably; although the capital inventory used in the manufacturing process has increased due to greater utilization of the machinery capacity, total capital inventory productivity is decreasing sharply.

Akhgar (2010), in his master's thesis titled "Estimating the elasticity of production factors and labor productivity rate in maroon oil and gas production company", has estimated the production function and the rate of labor productivity in the company using time-series data during 1989-2009. For this purpose, the reliability of the variables was tested using Augmented Dickey-Fuller test. Then, the error correction model was estimated using Engel-Granger cointegration method. The results showed that during the study period, the function is in the form of Cobb-Douglas as follows:

(Equation 1)

$$LQ = \text{۰/۳۱}LK + \text{۰/۶۶}LL + \text{۰/۶۱}LE$$

The elasticity of labor force, capital and energy are 0.66, 0.31 and 0.61, respectively. Wald test results show an increasing return to scale equal to 1.58. Ghalambaz, in his master thesis entitled "Estimating the production function and labor productivity rate in karoon oil and gas production company", has estimated the production function and the rate of labor productivity in the company using the time-series data during 1989-2009. For this purpose, the reliability of the variables was tested using Augmented Dickey-Fuller test. Then, the error correction model was estimated using Engel-Granger cointegration method. The results showed that during the study period, the function is in the form of Cobb-Douglas as follows:

(Equation 2)

$$LQ = 0/155LK + 0/645LL + 0/552LF + 0/997AR(1)$$

$$R^2 = 0/919$$

Also, the average productivity growth in Karoon Oil and Gas Production Company is 8.3%. The elasticity of labor force, capital and energy are 0.64, 0.15 and 0.55, respectively. Wald test results show an increasing return to scale equal to 1.34.

Marzieh Varzeshi (2008), in his master's thesis titled "Measuring and analyzing the productivity of production factors in large industrial factories in Iran during the period of 1983-2006”, has estimated the total productivity of production factors using the production function method and evaluating the partial productivity of the production factors using the value added method. Analysis of the factors affecting the labor productivity shows that the variables per capita capital, R & D cost and the increased ratio of actual to potential production or, in other words, the reduced unemployed capacity have positive effect on labor productivity, whereas the human development index and the ratio of privatization to state budget do not have a significant effect on labor productivity.

Analysis of the factors affecting the labor productivity shows that the variables of average labor per unit of capital, R & D cost and the increased ratio of actual to potential production have positive impact on the capital productivity, while the interest rate to inflation (as an alternative for the gap between inflation rate and interest rate and the subsidies assigned to the capital) has a significant effect on the capital productivity. During the whole study period, the overall productivity of the production factors and the capital productivity have decreased and have average annual growth of (-0.59) and (-0.85) percent, respectively. It is while the labor productivity has increased with an average annual growth of (5.8%).

Ali Imami Meybodi and Zahra Izadi (2008), in their study, measured the technical efficiency and productivity in Iranian oil refineries during the period 2001-2007 using data envelopment analysis (DEA). In this article, the average technical efficiency of refineries in the country during the mentioned years was at most 88% in 2009 and at least 81% in 2003. Lavan Refinery has been operating efficiently during all the years and Isfahan Refinery was efficient for many years. The refinery of Tehran in 2001 and 2002 and Bandar Abbas Refinery for many years have had the least efficiency. Also, the technical efficiency of Bandar Abbas Refinery has been decreasing in such a way that dropped from 72% in 2001 to 56% in 2007. The results of productivity measurement indicate that total productivity have been mildly increasing from 2002 to 2007. In addition, in 2007, the total productivity has increased significantly as a result of technological changes, and therefore the main factor in improving productivity was considered technological advancement.

Mahmodzadeh and Asadi (2007) studied the effects of information and communication technology on the growth of labor productivity in Iranian economy. In this study, considering experimental and theoretical models, the labor productivity function was estimated in terms of ICT and using the time-series data of 1971-2003 and ordinary least square method (OLS). The estimation results show that total productivity and non-ICT capital have the most impact on labor productivity in the Iranian economy. The effect of human capital and ICT capital on labor productivity is positive and significant, but their effect is lower than that of variables. The results of this study on ICT are consistent with the most empirical studies in developing countries.

Masayuki Morikawa (2010) examined the effect of labor unions on productivity, profits and wages in more than 4,000 industrial and non-industrial companies over the period 1998-2004. The data were analyzed based on some revised information extracted from the structure of job and activity (the Ministry of Economy and Industry) and the Institute of Management (International Labor Organization) and then estimated using ordinary least squares method. These sectors have started their activities since 1991, and each year study more than 25,000 industrial and non-industrial companies with more than 50 employees.

The estimation results show that:

- There is a significant positive relationship between the formation of labor unions in Japanese industrial and non-industrial companies and productivity and wages.
- There is a weak relationship between the formation of labor unions in industrial and non-industrial companies and the profitability of companies.

- The relationship between the employment growth in companies and the formation of labor unions depends on the number of part-time workers, to the extent that reduction in the number of part-time employees in the companies with union membership is greater than that of non-unionized companies, which depends on the willingness of this group of workers to form such unions. According to the surveys, the number of part-time employees in the companies with union membership decreases by about 0.3% per year while it is increasing by 1.1% per year in non-unionized companies.

Tzu- Pu Chang,Jin Li Hu (2010) investigated the changes in total productivity of energy factors, energy efficiency and technical progress in 29 provinces in China by calculating total-factor energy productivity index (TFEPI) during the period 2000-2004.

The variables influencing this index include human capital, GDP, the mixed energy (oil, natural gas, electricity and coal) and region (according to the development strategy of the western nations, these 29 provinces are divided into three eastern, western and central regions) and the productivity index in each region was estimated using the least squares method (OLS).

The results are as follows:

- Total-factor energy efficiency was declined by 1.4% per year from 2000 to 2004 (especially 3.2% between 2001 and 2002).
- Energy efficiency was improved by 0.6% per year during this period (with the exception of the period 2001-2003 with a negative growth rate).
- The technical progress of energy was reduced by 0.2% per annum (in fact, the decline in productivity resulted from a reduction in technical progress not energy efficiency).
- The eastern part of Japan was more productive than the other two.
- Increased GDP by developing secondary industries has a positive effect on productivity.
- Increasing the share of mixed energy, especially electricity, increases productivity.
- Increasing human capital indirectly increases productivity.

Sveinn Agnarsson et al. (2009), in a study, estimated the production function of Iceland fishing fleets in the period 1989-1994 using panel data and ordinary least squares (OLS).

The data includes annual observations of nine fishing fleets from 1994 to 1989 and contains the data on ship characteristics (size and length of the ship, engine size and lifetime), costs, sales and quantities of fish caught (Capelin mullet and Herring mullet) in tons. According to Fisheries Society (FI), about 40 boats were classified as fishing fleet in those years. Thus, our sample includes 25% of the population. The estimation results are as follows:

- Unexpectedly, the engine size parameter is negative, which means that the ships with large engines have more access to fish than small ones.
- The engine lifetime is negative, which indicates the harmful effect of an old engine on the total intake of ships.
- The parameter of Hering mullet's share is significantly positive, while it is not significant if combined with the Capelin mullet. This illustrates the fact that if the ships are normally operated, all of their caught fishes are Hering mullet, and the Capelin mullet contains a small percentage of their catches.
- In general, the total fish quota per year depends largely on estimates from fish eggs to explain the results.

Halpern et al (2009) examined the effect of imports on productivity in manufacturing companies in Hungary during the years 1992 to 2003 using the Cobb-Douglas production function.

The results show that:

- Increasing imports has a major impact on productivity improvement, to the extent that increasing the share of imports from zero to 100% increases productivity by 40%.
- The remaining 60% of the productivity increase is due to imperfect substitution between goods. So $\theta = 9/4$ which indicates the small elasticity of substitution of foreign and domestic products.

- The reduction of import tariffs in this study has a significant effect on productivity improvement, which causes the entry of new companies to the market of imported goods.

The researchers suggest that the context for importing capital goods to the country should be provided for further increase in productivity.

Dupuy& Marey (2008) investigated the changes in skilled labor productivity in the United States. Using the U.S data from 1963 to 2002, they found that decreased elasticity of substitution between skilled and unskilled labor force in the late 1970s decreases the productivity improvement trend. The increase in the elasticity of substitution in the 1990s accelerated the process of productivity improvement at this decade.

Andre Varella Mollick and Rene Cabral (2008) studied the effects of labor productivity and total factor productivity (TFP) on employment in 25 manufacturing industries in Mexico using panel data techniques and Cobb-Douglas production function during the period 1984-2000. It should be noted that among 28 industries, 3 cases including Code 354 (different products of petroleum and coal), Code 323 (leather goods) and Code 353 (oil refineries) were excluded due to a negative impact on fixed capital and only 25 industries were examined. The results show that the increase in total factor productivity and labor productivity on has a positive effect on the employment of small capital industries in Mexico. The factors such as increased wages, duty cycle and the implementation of NAFTA should be used to improve productivity in the employment. The above results are inverse in large capital industries.

Research Methodology

The use of econometric models to analyze economic relations has a history of more than half a century. Econometric models have been developed during this period and their use also has increased significantly. This development and increased application is both due to the promotion of economic knowledge and theory and thanks to the rapid development of statistical methods and tests. In addition, the significant boost in computational power of computers and the emergence of advanced software applications, along with improving the quality of statistical data and survey, had an important role in the widespread use of econometric models. It should be said that, despite the limitations of mathematical models to reflect the comprehensive and thorough economic behavior of human societies, there are no tools better than macro-econometric models to analyze economic developments and observe the possible effects of economic policies. In the present study, time-series data and regression analysis have been used. In this regard, Karoon Oil and Gas Production Company as the largest oil and gas production company in the country is selected as the research subject and its production function has been estimated during the period 1989-2011. For this purpose, the reliability of the variables was tested using Augmented Dickey-Fuller test. Then, the error correction model was estimated using Engel-Granger cointegration method.

The time series models often used for short-term predictions essentially explain the behavior of the variable based on its past values and possibly the past values of the other variables we would like to predict. These models are able to provide accurate estimates of the variables, even in cases where the underlying economic model is unclear.

Assume that y_t is a random time series with the following features:

(Equation 3)

$$E(y_t) = \mu$$
$$Var(y_t) = E(y_t - \mu)^2 = \delta^2$$
$$Cov(y_t, y_{t-k}) = E[(y_t - \mu)(y_{t-k} - \mu)] = \gamma_k$$
$$Corr(y_t, y_{t-k}) = y_k / \delta^2 = \rho_k$$

Where the mean μ, variance δ^2, covariance γ_k and correlation coefficient ρ_k are the constant values independent from the time t. Now suppose we change the interval, so that y change from y_t to y_{t-m}. In this case, if the mean, variance, covariance and correlation coefficient y did not change over time, it can be said that the time series variable y_t is reliable.

Types of reliability tests used in this study include unit root for reliability, Dickey-Fuller Test, Augmented Dickey- Fuller Test, Phillips and Perron, Cointegration Unit Root and reliability based on autocorrelation chart.

Experimental results

The use of econometric methods for empirical works is based on the reliability of variables. The studies show that this assumption is false about many economic time-series and most of these variables are unreliable. Therefore, in accordance with the cointegration theory in modern econometrics, it is essential to inquire about their reliability or unreliability. For this purpose, we use Augmented Dickey-Fuller unit root test. The results of the ADF test at the first level and difference of time-series of production functions are provided in table (1) and in appendix. Based on the tests, we conclude that the null hypothesis (the existence of unit root) is not rejected for any of the variables and all the variables are unreliable in the data. However, results of repeating the test on the first difference of the variables showed that the unreliability of all variables is rejected after a differencing. Therefore, based on Dickey- Fuller Test, all variables in the model are the function of first-class collective production. Symbol D represents the first difference.

Table (1). The results of the ADF test on time-series data

Variable	Dickey Fuller τ statistic	MacKinnon critical value	Intercept	Process	Pause	Result
Q	-2/078648	-3/644963	does not have	does not have	1	Unreliable
DQ	-5/246817	-3/644963	does not have	does not have	1	Reliable
L	2/612089	-3/632896	does not have	does not have	1	Unreliable
DL	-5/064980	-3/644963	does not have	does not have	1	Reliable
K	-2/647245	-3/644963	does not have	does not have	1	Unreliable
DK	-3/706912	-3/644963	does not have	does not have	1	Reliable
F	-2/288568	-3/658446	has	Has	1	Unreliable
DF	-3/696194	-3/690814	has	Has	1	Reliable
LQ	-2/714377	-3/658446	has	Has	1	Unreliable
DLQ	-5/053470	-3/644963	has	Has	1	Reliable
LL	0/561826	-3/632896	has	does not have	1	Unreliable
DLL	-4/075871	-3/644967	has	does not have	1	Reliable
LK	-1/343585	-3/632896	does not have	does not have	1	Unreliable
DLK	-3/828387	-3/644963	does not have	does not have	1	Reliable
LE	-1/391339	-3/690814	does not have	does not have	1	Unreliable
DLE	-4/088997	-3/690814	does not have	does not have	1	Reliable
LLLK	0/424081	-3/632896	does not have	does not have	1	Unreliable
DLLLK	-4/208746	-3/644963	does not have	does not have	1	Reliable
LLLFE	0/047373	-3/632896	does not have	does not have	1	Unreliable
DLLLE	-4/357330	-3/644963	does not have	does not have	1	Reliable
LKLE	-0/8021890	-3/690814	has	Has	1	Unreliable

DLKLE	221 643 /4	690 814 /3	has	Has	1	Reliable
LK ^{2}	-1/378249	-3/632896	does not have	does not have	1	Unreliable
DLK ^{2}	-3/821447	644 963 / 3 -	does not have	does not have	1	Reliable
LL ^{2}	-0/761602	632 896 /3	has	does not have	1	Unreliable
DLL ^{2}	-4/008096	644 963 /3	has	does not have	1	Reliable
LF ^{2}	-1/377911	690 814 / 3 -	does not have	does not have	1	Unreliable
DLF ^{2}	-4/075852	690 814 / 3 -	does not have	does not have	1	Reliable

(Source: Eviews Software Output)

Now, we use Engel-Granger cointegration test in order to show that the estimated regression is not false and the test statistics F and t are valid. Consider two time-series Y_t and X_t that both are I(d). Normally, any linear combination of Y_t and X_t is I(d). But if there were constants such as α and β in a way that the disturbing term of regression (i.e. $x_t\beta$ - U_t= y_t-α) has a mass order less than d, for example I (d-b) (b> 0), then according to the definition of Engle and Granger (1987), Y_t, X_t are cointegrated with order (d-b). According to the above definition, if Y_t, X_t both are of collective order like I(1) and Ut~I(0), then they will be two cointegrated time-series of order CI (1,1). This definition can be augmented to the cases with more than two time-series.

Engel-Granger and Augmented Engel-Granger tests are performed as follows: first, we estimate the regression using OLS method, then we examine the reliability of the residual expressions using DF or ADF methods. if the residual expressions were reliable, it is concluded that the variables are cointegrated.

For the two variables Y_t and X_t, the test is done in the following manner:

- **Step One**: finding convergence of the two variables using unit root

1. If the order of convergence of the two variables is equal, cointegration is possible and we go to step two.
2. If the order of convergence of the two variables is not equal, the variables may not be cointegraetd.
3. If two variables are static, the test process stops, because the standard regression technique could be used for static variables.

- **Step Two**: If two converged variables are of the same order, for example I(1), the estimation by OLS indicates the long-term equilibrium equation.

(Equation 4)

$$Y_t = \beta_0 + \beta_1 X_t + \varepsilon_t$$

- **Step Three**: the equilibrium error for the two cointegrated variables should be static. Thus, ADF reliability test should be done. This test is performed based on the following equation.

(Equation 5)

$$\Delta e_t = \delta e_{t-1} + \sum_{i=1}^{q} \delta_i \Delta e_{t-i+1} + \gamma_t$$

However, the table of critical values is different from the tables used for unit root test of a single series, because if the variables are not co-integrated, then the estimator OLS show a reliable picture of the residuals as much as possible. If the same critical tables of DF and ADF tests for a single series are used, the null hypothesis on the lack of cointegration is wrongly rejected in most cases. In order to correct this bias, Engle and Granger (1987) and McKinnon (1990) calculated critical values for the unit root tests on the residuals by Monte Carlo methods and then presented these values in tables. Therefore, the above tests are known as Engel-Granger and Augmented Engel-Granger tests.

Engel-Granger co-integration test method have become famous for two reasons. First, it is relatively simple task to estimate the long-term model by OLS and then perform the unit root test on the regression error terms. Second, estimation of the long-term model coefficients is the first step to set and estimate a short-term error correction model (ECM) that will be explained below. ADF test on residuals is given in the Cobb-Douglas function in table (2). As can be seen, the test statistic value is -4.2150 which is considerably smaller than the critical value with a probability of 5%, i.e. 3.6736. This shows the reliability of residuals and thus, the cointegration of the variables.

Table (2). ADF test results on residuals in the Cobb-Douglas function

ADF Test Statistic	- 4 21 50 98	1% Critical Value *		- 4 . 5325
		5% Critical Value		- 3 . 6736
		10% Critical Value		- 3 . 2773
* MacKinnon critical values for rejection of hypothesis of a unit root.				
Augmented Dickey-Fuller Test Equation				
Dependent Variable: D (U)				
Method: Least Squares				
Date: 01/22/13 Time: 23:58				
Sample (adjusted): 1370 1388				
Included observations: 19 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
U (-1)	-0.446782	0.202091	-2.210798	.0410
D (U (-1))	0.181760	0.234498	0.775101	.4489
R-squared	0.223857	Mean dependent var		0.015637
Adjusted R-squared	0.178201	SD dependent var		0.863697
SE of regression	0.782969	Akaike info criterion		2.447852
Sum squared resid	10.42168	Schwarz criterion		2.547267
Log likelihood	-21.25460	F-statistic		4.903171
Durbin-Watson stat	1.875280	Prob (F-statistic)		0.040760

(Source: Eviews Software Output)

Wald test: this test applies certain restrictions on the coefficients of estimated function. One of its important applications is to test return to scale ratio. For this test, we need to review the estimated function once again:

(Equation 6)

$$LQ = 0/182LK + 0/434LL + 0/589LE$$

In the Cobb-Douglas production function, return to scale is calculated by the sum of elasticities.

$$0/182 + 0/434 + 0/589 = 1/205$$

The degree of return to scale

Returns to scale in Aghajari Oil and Gas Production Company is 1.205. since this value is larger than 1, there is an increasing return to scale (IRS). It means that one percent increase in all production inputs simultaneously will increase the product by 120.5%. To accept or reject this claim, the Wald test is used. The assumptions of this test include:

(Production has constant returns to scale)

$$H_0 = \alpha + \beta + \gamma = 1$$

(Production does not have constant returns to scale)

$$H_1 = \alpha + \beta + \gamma \neq 1$$

In this test, we decide on accepting or rejecting the null hypothesis based on the results of F and chi square tests. If the probability values of these statistics are less than 0.05, we reject H0 at 95% confidence level. The results of the Wald test are presented in Table (3).

Table (3). The Wald test results

Wald Test:			
Equation: COBBDOUGLAS			
Null Hypothesis:	1. 205 C (2) + C (3) + C (4) =		
F-statistic	7 0.607791	Probability	0.00 5571
Chi-square	6 . 5474 91	Probability	0.00 4247

(Source: Eviews Software Output)

According to the above table and the values of F and Chi square tests equal to 7/6777 and 6/5474, and their probability coefficients equal to 0/005571 and 0/004247, it can be concluded that H0 is strongly rejected, and this result is completely consistent with the model estimation results, which is the increasing return (and not constant return) to scale.

Short-term model estimation

The first step to set and estimate a short-term model is determining Error Correction Mode (ECM) that shows the short-term dynamics and the speed of long-term adjustment. Therefore, the ECM model estimation is necessary to obtain the short-term model.

The co-integration between a set of economic variables provides the statistical basis for using Error Correction Models (ECM). These patterns have got growing reputation in experimental works. The major reputation of error correction models is linking the short-term fluctuations of variables to their long-term equilibrium values. When two variables y_t and x_t are cointegrated, there is a long-term equilibrium relation between them. However, there might be some imbalances in short-term. In this case, the error term of the following equation can be considered as the equilibrium error.

(Equation 7)

$$Y_t = \beta X_t + U_t$$

(Equation 8)

$$U_t = Y_t - \beta X_t$$

Now, this error can be used to link the short-term behavior Y_t with its long-run equilibrium value. For this purpose, the following model can be set.

(Equation 9)

$$\Delta Y_t = \alpha_0 + \alpha_1 \Delta X_1 + \alpha_2 \hat{U}_{t-1} + \varepsilon_t$$

Where $\hat{U}_{t-1}$ is the residual of estimated regression with a time lag. This model is known as error correction model (ECM) where the changes in Y_t have been linked to the equilibrium error in previous period. When Y_t and X_t that both have a degree of convergence I (1), are co-integrated, then the residuals U_t of equation (4-21) have zero order of convergence I(0) and they are reliable. As a result, it is possible to estimate this model without fear of spurious regression using OLS estimates and the statistics t and F.

In short, this estimation is based on a two-stage modeling strategy as follows:

First step: the parameters related to long-term model are estimated using the data of variable level, then the null hypothesis on the lack of co-integration between variables are tested. Therefore, a set of co-integrated variables will be found and a long-term equilibrium relationship is provided.

Second step: The Error Correction Term (ECT) is the error term of the static long-term regression model $\hat{U}_t$ which is used as an explanatory variable in the ECM model. Then, we determine the short-term dynamics through necessary tests. ECT coefficient shows the speed of adjustment to the equilibrium and is expected to be negative. First, this method was introduced by Sargan (1984) and then rose to fame well-known by Engel and Granger (1987). In spite of being simple and low cost, this approach also has some drawbacks. Although OLS estimators of the above cointegration regression are consistent, these distributions are not normal and strongly depend on other model parameters. In addition, the bias of estimators in small samples can be substantial. Therefore, the statistical inferences might be misleading and wrong decision are made about the variables to be inserted in the model and the bounds to be applied. In the second stage, the bias of estimators is transferred to the error correction term and may also affect short-term model parameters.

Now, in order to set the error correction model of the estimated function (Cobb-Douglas model), we put the error terms of the co-integrated regression in Table (4) with a time interval as an explanatory variable along with the first difference of the other model variables. Then, we estimate the model coefficients using the method OLS. The results are shown in Table (4).

Table (4). The results of ECM model estimation

Dependent Variable: D (LQ)				
Method: Least Squares				
Date: 01/22/13 Time: 20:27				
90 Sample (adjusted): 1369 13				
Included observations: 22 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D (LK)	0.160052	0.121669	1.051566	0.0034
D (LL)	0.398278	0.246680	1.092963	0.0087
D (LE)	0.525447	0.253540	1.076159	.0013
ECM (-1)	-0.524560	0.172650	-1.994223	.0043
R-squared	0.996815	Dependent Mean var		0.163956
Adjusted R-squared	0.990593	Dependent SD var		1.735652
SE of regression	0.141745	Akaike info criterion		-0.790087
Squared Sum resid	0.567215	Schwarz criterion		-0.589234
Log likelihood	19.90087	F-statistic		100.0678
Durbin-Watson stat	1.785626	Prob (F-statistic)		0.000462

(Source: Eviews Software Output)

As it is obvious, all model coefficients are absolutely significant. The coefficient of determination is 0.99 that shows the high explanatory power of the model. The coefficient of error correction term (ECT) is equal to -0.52, which means that 52% of the imbalance in each period is adjusted. The deviation to equilibrium occurs fast.

Comparing the coefficients of production factors in short-term and long-term functions indicates that there is little difference between these coefficients. The signal of all coefficients are consistent with theoretical expectations. The coefficient of capital elasticity in short-term is 0.16 which has a slight difference with the long-term elasticity of capital (0.182). Labor elasticity coefficient is equal to 0.398 which is equal to the same factor in the long-term model (0.434). Energy elasticity coefficient is equal to 0.525 which is slightly different with the same factor in the long-term model (0.589).

The estimation of labor productivity rate

Consider that production growth is continuous. According to the definition of growth rate, if Y is a function of time as Y = f (t) is, then we have:

(Equation 10)

$\rho = \frac{y'}{y} = r$ In fact, y' is the change rate of Y and $\frac{y'}{y}$ is the change rate of a unit of Y, i.e. the growth rate is r. But the above equation is a differential equation, then we have:

(Equation 11)

$$\frac{dy/dt}{Y} = r \Rightarrow \frac{dy}{Y} = r.dt$$

This is a separate differential equation:

(Equation 12)

$$\ln y = rt + \ln c$$

(Equation 13)

$$\ln \frac{Y}{c} = r.t \Rightarrow y = ce^{rt}$$

If we presume that $y_0 = y$ at t = 0, then we have:

(Equation 14)

$$y = y.e^{rt}$$

Considering the oil price that was 19.9$ in 1999 and 50$ in 2009, we have:

$t = 9$, $y = y_{88}$, $y_0 = y_{78}$

y_{78}= (قیمت دلار به ریال*قیمت نفت درسال ۷۸ به ریال*(مقدار تولید درسال ۷۸) / (نفرساعت نیروی انسانی) = (۲۹۱۱۱۸٤۰۰ *۱۹/۹*۸٦۵۰) / (۱۷۳۹٦۳۰)

y_{88}= (قیمت دلار به ریال*قیمت نفت درسال ۸۸ به ریال*(مقدار تولید درسال ۸۸) / (نفرساعت نیروی انسانی) = (۲۷۰۳٦۵۱۸٦*۵۰*۹۵۰۰) / (۲۷۸۷۸٤۰)

(Equation 15)

We convert the values to the fixed price of the year WF using the consumer price index (CPI). Thus, we will have: y_{1999}=131889 and y_{2009}=188365. So we have:

(Equation 16)

$$\frac{\ln y - \ln y_0}{t} = r \ln e$$

If we take an anti-log from the above equation and then multiply the decimal part by 100, the average rate of labor productivity growth is calculated (r=1.078). Then, the average productivity growth in Aghajari Oil and Gas Production Company is 7.8%.

Conclusion

The main objective of this study was to estimate the production function and the labor productivity rate in Aghajari Oil and Gas Production Company. The first step was to analyze the data and determine the status of the data in terms of their static and dynamic nature and degree of convergence. It was done by Augmented Dicky-Fuller test (ADF). The main idea of cointegration analysis is that although many of economic time-series might be unreliable, a linear combination of these variables in the long-term may be reliable. There are several ways for cointegration test. In Engel-Granger cointegration test, first the regression equation is estimated by OLS and then apply the unit root test on the residuals. If the residuals are reliable, then the cointegration is accepted; otherwise, the regression equation is unacceptable. The special limitations of Engel-Granger method including the problem of variables with convergence orders higher than I(1), made the economists to utilize Johansen-Juselius method. According to the results, the variables affecting production in Aghajari Oil and Gas Production Company, include capital, labor and energy. The elasticity of these variables in the long-term is obtained by OLS equal to 0.182, 0.398 and 0.589, respectively, which indicates positive production elasticity to the mentioned inputs. In addition, the results of Wald test showed that return to scale in Aghajari Oil and Gas Production Company is increasing and equal to 1.205.

Regarding the increase in production and productivity in Aghajari Oil and Gas Production Company, the following items are suggested:

- Estimating the cost function for Aghajari Oil and Gas Production Company and applying the drilling and exploration costs on it, and finally estimating the production function.
- Estimating the production function and calculating the labor productivity rate in other companies affiliated to the Oil Ministry and comparing them with Aghajari Oil and Gas Production Company.
- The results of the production function estimation with increasing return to scale ratio indicate that the development of the company results in economies of scale. Therefore, according to the increasing demand of the market, Aghajari Oil and Gas Production Company can, in the first instance, increase human resource inputs and secondly, increase its capital in order to expand its business and thus produce more energy for production.
- The reason for relatively large energy coefficient in Cobb-Douglas Production Function is that the production values in gas and liquid-gas units as well as increasing the gas pressure heavily depend on electricity and the production values have been calculated in B.T.U. As it was observed, the conversion coefficient of gas and liquid-gas is high. Therefore, it is recommended to evaluate and implement energy reduction solutions through a committee under the supervision of the Managing Director.

Regarding the increase in labor productivity in organizations, the following cases are proposed:

- Introducing managersmanagers with efficient methods of operation, healthy equipment and tools, a balanced work environment, an appropriate organizational structure and, most importantly, providing suitable platforms for the optimal use of qualified and deserved human resources to increase productivity in organizations.
- Increasing consistency between jobs and workforce skills. In this case, it seems that training human resources with irrelevant skills or replacing experts with irrelevant workforce can increase the productivity of the labor force.

- It is possible for all employees at all levels and organizational positions to continue higher education without any discrimination and thus a special quota in universities and higher education institutions should be designated for this purpose. Also, the permission for days off and education missions and the tuition fees of those employees who accepted should be provided.
- Considering the interest and desire of employees for early retirement and preparing the ground for early retirement of some of inefficient and non-specialist forces (5 to 10 years of leniency), and employing young specialists people with higher education for increasing the productivity.
- Increasing the motivation for doing useful works through establishment of a relationship between the level of wage and salary with productivity level.
- Improving the quality of education offered to the workforce, expanding in-service training.
- Paving the ground to expand the use of ICT in the organization.

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