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The Measurement of Input Elasticity: a Case Study at SAIPA Automobile Manufacturing

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Abstract

The main objective of this survey is to examine the efficiency and productivity in SAIPA Automobile Manufacturing as the second the largest car producer in Iran. This company is one of most important company in Iran based on the share of GNP and high rate of employment on it. The research answers two specific questions: (i) what levels are the marginal productivity of labour and capital? (ii) How big are the output elasticity with respect to input? The cobb-Douglas production function was estimated for SAIPA Automobile Company to show the relationship between input and output applying the time series data from 1990 to 2019. The research found out the output elasticity with respect to labour and capital are 0.1 and 0.72, respectively. Consequently, the company has experienced the decreasing returns to scale (DRS) in the period of the study. Based on the amount of elasticity, output changes 0. 1 percent by one percent change in labour. Also, one percent changes in capital makes 0.72 percent change in output. The study states to get the input use efficiency the empirical policies are using modern technology and decreasing input use.

Keywords

Cobb-Douglas Function, SAIPA Company, Output, Input, Automotive Industry.

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Introduction

Automotive industry is one of the most important sectors in Iran. The fifth king of Iran, Muzafarddin Shah, purchased the first automobile, in 1902. It was brought in Belgium. The imports of cars went up by 1920. It can be said Iran stated to establish auto industry by importing foreign cars manufacturers at 1960s (Ahmadi & Sarhangi, 2009; Mahmoudzadeh, Mansour, & Karimi, 2013; Moghbel & Qoudarzi, 2004). Iran National Company was the first car manufacturer in Iran. The objective of it was to make bodies parts of cars, Benz, which were supplied to the market in 1963 (Ahmadi & Sarhangi, 2008; Manteghi, 2005). It was a private company but enter to the public sector since Islamic Revolution in 1979 and its name became Iran Khodro Company. Saipa Company is the second largest car maker in Iran. It was established in 1966 as a private company in partnership with the Citroen French Company with the capital of 160,000,000 rials. The first two cars of this company were Vanet Aka and Jeean and over the past decade it has produced more than 30 kinds of vehicles. In 2013, its share in the total automotive production was 39.3%. Saipa, like Iran Khodro, was also nationalized after the Islamic Revolution, in 1979, but it now jointly owned by the government and the private sector with the former holding the majority shares. The study shows the contribution of auto industry in the Iranian industry has increase year by year but with fluctuations, as the share of car production in the whole industry has increased from 10.5 percent in 1999 to 21 percent in 2016. Table 1 exhibits the quantity of production in the automobile part between 2005 and 2019.

Table Production statistics in the auto industry, 2005-2019

Year	Cars	Commercial Vehicles	Total	% year on year change
2005	923,800	153,390	1,077,190	36.6
2006	800,000	104,500	904,500	10.7
2007	882,000	115,240	997,240	10.3
2008	1,048,307	225,474	1,273,781	27.7
2009	1,170,503	223,572	1,394,075	9.4
2010	1,367,014	232,440	1,599,454	14.7
2011	1,412,803	236,508	1,649,311	3.1
2012	856,927	143,162	1,000,089	-39.3
2013	630,639	113,041	743,680	-25.6
2014	925, 975	164871	1,090,846	46.68
2015	884,866	97,471	982,337	-9.9%
2016	1,074,000	90,710	1,164,710	18.6%
2017	1,418,550	96,846	1,515,396	18.19%
2018	1,027,313	68,213	1,095,526	-40%
2019	770,000	51,060	821,060	-25%

Source: OICA annual reports (www.oica.net)

Car Production has increased year by year however with fluctuations mostly because of economic sanctions against Iran. The total costs of production comparing with the total income is high based on the statistics views in the Iranian auto industry. That indicates that the industry applies numerous input for producing a certain product. This phenomena generates the question: what issues makes this drawback. For checking and solving that, the

business managers have to distinguish the productivity of each input. Productivity is a general concept which its improvement is vital for improving the life quality. So, it is a major goal for all of nations in the world. The research answers specific question: what levels are the elasticity of labour and capital?

To recognize rest of the research best, it is needed to review several fundamental aspects which one is elasticity. It is one of the most important and empirical concepts. Generally, the ratio of percentage change of two variables is named elasticity. If Y = f(x), then the elasticity, e_{xy}, can be illustrated by following equation:

$$e = \frac{\%\Delta Y}{\%\Delta x} \quad \text{Or} \quad e = \frac{\Delta y}{\Delta x}\frac{x}{y}$$

In fact, the elasticity shows if the variable x changes one percent leads to change in what percentage of the y variable. For example, the elasticity between x and y, e_{xy}, equals to three once one percent increase in x causes three percent increase in y. Many papers in economics to examine firms behaviors assumes that production functions of firms are in form of the Cobb-Douglas production function which first introduced by Charles Cobb and Paul Douglas [3,5,6 and9]. It is written as follow:

$$Q = F(L, K) = AL^{\alpha 1}K^{\alpha 2}$$

Where, A, α_1 and α_2 are parameters. In this function, α_1 and α_2 display the production elasticity of capital and labor, respectively. In this form, the marginal product of labor can be estimated as the following equation [1, 2 and 4]:

$$MP_L = \propto_1 AL^{\alpha_1 - 1}K^{\alpha 2}$$

And the marginal product of capital is obtained as follow:

$$MP_L = \propto_2 AL^{\alpha_1}K^{\alpha_2 - 1}$$

Hence, the marginal rate of technical substitution between labor and capital, $MRTS_{LK}$, is:

$$MRTS_{LK} = \left(\frac{\alpha_1}{\alpha_2}\right)\left(\frac{K}{L}\right)$$

The main objective of this paper is to evaluate measure the efficiency and productivity at Saipa Automobile Manufacturing. It has many benefits for the Iranian auto decision makers to take a good decision to reduce the costs and increase the productivity in the sector.

The main hypotheses in the study are as follow:

1. The labor elasticity at Saipa Automobile Manufacturing is statistically significant and positive during period 1990 to 2019.
2. The capital elasticity at Saipa Automobile Manufacturing is statistically significant and positive during period 1990 to 2019.

Materials and Methods

The paper uses the descriptive and analytical methods. Achieving the aim theoretical discussions and empirical studies was conducted using library methods. The required data, the related background information on empirical studiers and literature was collected by internet and library ways. The statistical data are taken from statistical data of Central Bank and Saipa Auto Manufacturing which is the second biggest car company in Iran. For achieving the goal the time series data are applied from 1990 to 2019. After collecting the secondary data, it is necessary to determine to be or not to be the stationary for the data. Unit root test of Augmented Dickey-Fuller (ADF) is applied for it. Many economic variables need to examine based on a long-run economic relationship between them. The framework of co-

integration is to discuss the regression models for all variables which are non-stationary means that it related to the data with unit root (Banerjee, Dolado, Galbraith, & Hendry, 1993; Engle & Granger, 1987). It is possible for some variables which are unit root or non-stationary, there be a given linear combination of those variables to be stationary. In this case, the unit root variables are called co-integrated (Lise & Van Montfort, 2007; MacKinnon, 2010). Hence, there is a long-run equilibrium relationship between the co-integrated variables. In fact, the co-integration methods are used to determine a long-run relationship between the variables (Engle & Yoo, 1987; J. Wooldridge, 2012). In this method first the variables stationary is tested, then if the variables are non-stationary, the co-integration test will be applied for them. Two methods Engel-Granger and Johansen are commonly used for the co-integration test. The Engel-Granger method examines just one long-run relationship between two variables. This method will be disrupted; if the number of variables is greater than two because in this case is just considered one error term in the equation also the differencing time series data will cause to remove some data. The Johansen method is better than the Engel-Granger method. This method does not use the differencing approach in order to make the variables to be stationary.

In summary, if the result of the Dickey-Fuller Test proves the existing of unit root, the first step is the co-integration test on residuals. If the nonstationary variables are not co-integration, the equation can be estimated using the first difference. Anyway, the nonstationary variables which are co-integration, the equation can be derived using original unit. It is necessary to know the Error Correction Models (ECM) and vector autoregressive (VAR) models, before discussing about the Engel-Granger and Johansen approaches (Baltagi, 2008; Bisaglia & Procidano, 2002; Cheng & Lai, 1997; Verbeek, 2008).

Error Correction Model (ECM)

Error Correction Model, ECM, believes that often there is an equilibrium relationship in the long-run between two variables which may not be equilibrium in the short run. This model adapts behaviors of short-run and long-run (Ghosh, 1993a, 1993b; Urbain, 1993).

Consider that there is a long-run relationship between two variables X_t and Y_t as the following form:

$$Y_t = KX_t$$

where K a constant coefficient. As an instance, Ando and Modigliani formulated the life-cycle hypothesis which states a fixed fraction of wealth is consumed in the long-run.

The following equation will obtain after taking logarithms from two sides of the above equation (Asteriou & Hall, 2011; Urbain, 1993):

$$\ln Y_t = \ln K + \ln X_t \qquad \text{or} \qquad y_t = k + x_t$$

Here, the lowercase letters show the logarithms of variables. Since $y_{t-1} = k + x_{t-1}$, if the Δ states the variable change from one period to the next period so the new form of above equation is of the following equation (Asteriou & Hall, 2011; Banerjee et al., 1993; Urbain, 1993):

$$\Delta y_t = \Delta x_t$$

The following short-run model shows the adjustment form with one period lagged.

$$y_t = \beta_0 + \beta_1 x_t + \beta_2 x_{t-1} + \alpha_1 y_{t-1} + u_t$$

To investigate the transformation conditions from short-run to long-run model, for all of t can be considered y^* instead of y_t and x^* instead of x_t also setting u_t equal zero for the long-run. After these substitutions the above equation will modified to following form (Asteriou & Hall, 2011; Urbain, 1993):

$$y^*(1-\alpha_1) = \beta_0 (\beta_1 + \beta_2) x^*$$

If be assumed $(1-\alpha_1) = (\beta_1 + \beta_2)$, we have:

$$y^* = k^* + x^*$$

where $k^* = \beta_0 / (1 - \alpha_1)$. If be considered $1 - \alpha_1 = \gamma = \beta_1 + \beta_2$

Substituting $\alpha_1 = 1 - \gamma$ and $\beta_2 = \gamma - \beta_1$ in the following equation:

$$y_t = \beta_0 + \beta_1 x_t + \beta_2 x_{t-1} + \alpha_1 y_{t-1} + u_t$$

and summarization it, we obtain:

$$\Delta y_t = \beta_0 + \beta_1 \Delta x_t + \gamma (x_{t-1} - y_{t-1}) + u_t$$

The above equation is a mechanism of the most simple error correction model. In this equation, the change in the dependent variable depends on the change in the independent variable as well as the gap between those variables in the prior period. It is necessary to apply the following stages to estimate this relationship (Banerjee et al., 1993; Chowdhury, 1993; Urbain, 1993):

The first stage is to take logarithms from the variables Y_t, X_t, ΔY_t and ΔX_t and the second stage is to determine the regression of Δy_t on a constant, Δx_t, x_{t-1}, y_{t-1}.

Vector Autoregressive Model (VAR)

Interdependencies between variables occur if the number of variables be more than two variables, in this case, must be investigated the relationship between these variables in a model of simultaneous equations system. If there are the lagged of variables in this model, it is called the system of dynamic simultaneous equations. In this system, some of variables are Endogenous variables and other variables are exogenous. It is necessary that the equations of this model be identified (Hansen & Johansen, 1992; Toda & Yamamoto, 1995; Verbeek, 2008). Since pre-judgment is not correct regarding which variables is endogenous or exogenous, was offered the vector autoregressive model (VAR). The following model is a simplest vector autoregressive model with two times series X_t, Y_t (Asteriou & Hall, 2011; Verbeek, 2008):

$$X_t = \alpha_1 + \sum_{i=1}^{m} \beta_{11(i)} X_{t-i} + \sum_{i=1}^{m} \beta_{12(i)} Y_{t-i} + \varepsilon_{1t}$$

$$Y_t = \alpha_2 + \sum_{i=1}^{m} \beta_{21(i)} X_{t-i} + \sum_{i=1}^{m} \beta_{22(i)} Y_{t-i} + \varepsilon_{2t}$$

The all of ε_t have the normal distributions with mean zero and constant variance. The above equation with K endogenous variables and m lagged can be written in the following form:

$$X_t = \alpha + A_1 X_{t-1} + A_2 X_{t-2} + \cdots + A_m X_{t-m} + \varepsilon_t$$

where X, X_{t-1}, A_i and ε_t are vector of variables (K×1), lag values of variables, coefficients matrix of the model (K×K) and error terms vector (K×1).

Then is used the Cobb- Douglas function representing the relationship between the value add of Saipa Company as a dependent variable and its factors of production, labor and capital, as the independents variables [12- 28].

To representing the model is applied the Cobb Douglas function as the following:

$$Q = F(L, K) = AK_{-1}{}^{\alpha 1} L^{\alpha 2}$$

Now, the paper takes the natural logarithm from two sides of above equation, so we can easily the following liner function:

$$Ln(Q) = \ln(A) + \alpha_1 \ln(K_{-1}) + \alpha_2 \ln(L)$$

Where

A = as a constant amount

ln(Q) = the natural logarithm of Saipa Company value added.

$\ln(K_{-1})$ = the natural logarithm of the capital stock in Saipa Company with one lag period.

ln(L) = the natural logarithm of the number of employees in Saipa Company.

Hence, the linear regression model can be used to estimate the production function in this research. The statistical population limits to Iran economy. The studied variables in this study are annual time series data mainly from 1991 to 2019. The study applies Eviews Software. Then significant of the model and coefficients investigates using appropriate statistical analyzes.

Results

First step, it is necessary to check the time series data is stationary or not which it can be provided in some ways using Eviews or other software. One of all is Unit root test of Augmented Dickey-Fuller (ADF) which is used by this survey. Due to the results of the ADF test, at 5% confidence level, all of the data are not stationary at the level but only the natural logarithm of capital is stationary at the level and the other variables in the natural logarithm of the variables are stationary at the first difference. In other words, however the Q and L variables have unit root test at the level but have not unit root test while the natural logarithm of the variables are used in the Cobb Douglas function [7 and 10].

The ADF test results are as come at the following table:

Table1. The results of ADF test

The names of variables	ADF statistics	The Critical Value at 5%	The Stationary at	Prob.
Ln(Q)	-5.963162	-3.622129	1st difference	0.0001
$\ln(K_{-1})$	-5.449345	-3.612567	Level	0.0000
Ln(L)	-4.288581	-3.622199	1st difference	0.0126

In order to estimate the relationship between the private sector investment and the effectives variables in Iran are applied the linear regression model. The function coefficients can be found from the below table [42 and 43]:

Table2. Coefficients of Model

Dependent Variable: LNQ
Method: Least Squares
Sample (adjusted): 1991 2019
Included observations: 29 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.230125	0.407280	10.38582	0.0000
LN K_{-1}	0.721551	0.037297	16.09751	0.0000
LNL	0.136709	0.834799	1.002256	0.3178

R-squared	0.926721	Mean dependent var	10.71758
Adjusted R-squared	0.919742	S.D. dependent var	0.260891
S.E. of regression	0.073910	Akaike info criterion	-2.255364
Sum squared resid	0.114619	Schwarz criterion	-2.108325
Log likelihood	30.06282	Hannan-Quinn criter.	-2.216399
F-statistic	132.7774	Durbin-Watson stat	0.692872
Prob(F-statistic)	0.000000		

And for this model we can write as follow:

Substituted Coefficients:

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LNQ = 4.23 + 0.7215*LNK + 0.136*LNL

Discussion and Conclusions

The results of the study show, in the model, the coefficients of the natural logarithm of the capital stock in Saipa Company with one lag period and the natural logarithm of the number of employees in Saipa Company are 0.721 and 0.136, respectively. Due to the information of above table α_1 is significant at %5 confidence level. But the coefficient of labor, α_2, isn't statistically significant. Indeed, these coefficients show the amount of elasticity of production

factors for Saipa Company. Hence, if the capital in Saipa Company increases one percentage then the production in this sector increases 0.721.

The coefficients of the variables are also statistically significant due to ANOVA test (see the ANOVA table as the follow):

Table 3. ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.391	2	.725	129.811	.000[b]
	Residual	.117	28	.005		
	Total	1.508	30			

a. Dependent Variable: lnQ

b. Predictors: (Constant), ln(L), ln(K)

Due to the ANOVA data in table 3, the Sig is near to zero so the correlations are significant among Saipa Company value added and the independent variables also the t-test statistic confirms it and also the value of R-Square is enough big which indicates the contribution of ln(L) and $\ln(K_{-1})$ on the natural logarithm of Saipa Company value added of Iran is 0.926721%. The closeness of R2 and Adj-R2, 0.919742%, shows the Goodness of fit of data. Generally, one of hypotheses is accepted and the other is rejected means that:

1. The labor elasticity in Saipa is not statistically significant and positive during period 1991 to 2019.
2. The capital elasticity in Saipa is statistically significant and positive during period 1991 to 2019.

The elasticity of labor is not significant in this study because the ratio of labor with respect to capital is high and also the labor in Saipa Company has not full efficiency. Many of employees in this sector are unskilled. This study estimates the factors elasticity of production in Saipa Company using the Cobb Douglas function during 1991 to 2019. This survey examines the changes in the production factors how much effect on the change in Saipa Company value added in Iran. The results of the study show that increasing capital in Saipa causes to increase Saipa Company value added. So the Saipa needs to support the Iran government more than the past.

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