# MEASURE AND ANALYZE TOTAL FACTOR PRODUCTIVITY INDEX IN AUTOMOTIVE INDUSTRY; (CASE STUDY: KERMAN MOTOR ASSEMBLES SALOON)

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**Abstract**

Changes in Successive periods of each country's GDP indicates the level of economic growth and prosperity, and growth could accelerate economic growth and social welfare. with respect to the necessity and importance of development in automotive sector across national industry and economy on one hand, and the necessity of measuring the performance of this industry one the other hand for planning so as to improve efficiency, productivity and competitiveness of productions in this sector, this study aiming at measuring and analyzing total factor productivity index in automotive industry (case study: Kerman motor Assemble saloon) using data envelopment analysis package and Malmquist productivity index, has been carried out. Essential statistics were gathered using documentary studies, interviews and meetings with experts in each unit. Extract Malmquist productivity index after homogenization of Statistics collected in four inputs and one output in 14 periods of time was carried out. Research findings showed that changes in productivity in assemble unit with aobut 0.914 was reduced. Meanwhile, mean of changes in technology showed technical performance with an ascending trend. In sake of Malmquist productivity index, Assemble saloon had the worst situation compared to all three units. Eventually, quantitative findings and analysis of qualtiative results of barriers and difficulties existing in units, applied and research suggestions to improve performance of these units were given to managers, scholars and politicians.

**Keywords:** automotive, productivity, efficiency, data envelopment analysis package, Malmquist productivity index

## Introduction

The automotive industry is one of the most important driving forces of economic growth in the twentieth century; with nearly a century of history in connections between this industry and other industries, this industry encompassing extensive experiences and strengthening position, mentioned with a large body of knowledge, technology and capital. Forty years ago Peter Drucker dubbed automotive industry "the industry of industries." Today, automobile industry, with nearly 50 million new vehicles produced each year, is still the world's largest manufacturing activity (Amini, 1998, pp. 5). Automotive industry of any state reflects thorough status of industries existing at that state. This manufacturing industry reflects all the industries existing in that state by which the quantitative and qualitative level across all industries such as metal, chemical and textile industry can be evaluated. Hence, a survey on the automotive industry found necessary. Automotive industry enjoys the most advanced

technologies across the world, and found a specific form at manufacturing stage due to being provided with the communications in the past and future. Given part of previous links, various needs of automotive industry to spare parts and Raw materials and components, include hundreds of industry and activity. In this regards, a number of industries assigns all manufacturing products and others assign some of their manufactures to automotive industry. Industries of Rubber, plastic, steel, leather, Cable, paint, electronics and thousands of small and big pieces of the manufacturer each alone produces one or more pieces of essential components for steel industry, needing to a big development of automotive industry so as to sustain on. In addition to such industries, other industries such as Gas stations, workshops, after-sales service, spare parts and so forth can be named. Through the development of automotive production, development in automotive industry can be acquired, strengthening the industry and then economy as a whole. With extensive communication between automotive industry and other industries, a strong communication particularly with the industries providing components would be made. This highlights the strategic importance of automotive industry, and development of supporting industries would be followed (Salimian, Khadem, 2007, pp. 335). Human's efforts have focused on automotive industries where the most outcome can be acquired with the least effort and facilities, this can be named desire to access the higher productivity. One of the indices being used more than other indices to evaluate entities' performance is the very productivity that is defined by means of ratio of outputs to inputs (Hossein zade Lotfi, et al. 2009, pp.30).

**Overviews of studies in the context of calculate and measure the efficiency and productivity of automotive industry**

Amini(1999) has addressed measuring and analyzing technical changes, efficiency and productivity across Iran Khodro Company (IKCO), using estimates of the production function, and then has considered Cobb-Douglas production function in Iran khodro. Eventually, it came to an end in this manner that efficiency at Iran Khodro Company (IKCO) has been 50%, indicating that Iran Khodro Company (IKCO) has used manufacturing capacities for about 5%. Thereafter, several approaches for a big improvement to advance efficiency and productivity of this industry have been proposed.

Study by Sanjabi(2003) addressed investigation of function of Production, cost and efficiency in Iran Khodro Company (IKCO) during 1984-2002. Using not related regressions, cost and production functions successively kept estimating. Finally, it was deduced that labor, capital and raw materials in the long run are inelastic, where just energy production is elastic.
Findings of research by Makoei et al.(2008) proposes non-parametric data envelopment analysis for the performance of companies with the same activity regarding financial criteria.

Empirical use of models was examined, and then the results of models, that is, performance of 29 automotive Assemble companies with the use of several financial ratios as output and Data Envelopment Analysis as a method without input, were compared. Finally, these two models were compared with the simple analysis model.
The results of this study indicate that the relative expression between the extent of efficiency of company and extent of operating profit and return exists. Further, there exists a positive significant relationship between company size and efficiency rating. Mean of assets in the companies under study in these three years kept increasing, indicating an increase in relative financial efficiency across automotive industry.

Study by Abolhasani(2006) has addressed measuring productivity of manufacturing process among auto makers using hours per vehicle index. He has taken step to recognize the method to calculate this index using data prevailing Iran Khodro Company (IKCO), and then codified other measurements to improve hours per vehicle index. Eventually, this study has addressed concurrent engineering in product design and manufacturing process.

Study by Dadkhah et al.(2010) has evaluated the active companies engaged in automotive manufacturing using data envelopment analysis package, then the relationship between efficiency and stock returns has been tested in these companies. Statistical population consists of companies accepted at Tehran stock exchange, and statistical sample consists of companies engaged at automotive manufacturing Industries. In this study, library data collection method, regression analysis, Test of significance β (slope of the regression line), Analysis of Pearson's correlation coefficient (r), A comparative test of two population means have been used. The results from this study indicate that there exists a significant relationship between relative efficiency and stock returns, cannot conclude that stock returns at efficient companies go over measure the stock return at inefficient companies. Study by Nasr Esfehani and Razavi(2010) has addressed efficiency and productivity of automotive companies.

Using statistics and information of automotive companies in 2004-2008, efficiency and productivity of automotive companies using data envelopment analysis package have addressed. The reason to choose five companies among all other companies was their high contribution to production and sale within the country.
The results of this study indicate decrease in productivity of automotive industry in the years research provided, changes at technical and scale efficiency at management as well as low speed of development in technology across automotive industry. The changes in terms of productivity provided with the classification of companies in order.

## Concepts

### Productivity

Productivity in a given culture has come to mean a utilization and efficiency (2012, www.jasjoo.com). The Organisation for European Economic Co-operation; (OEEC) has defined productivity(1950), Productivity is a fraction obtained by dividing the amount or value of product to the amount or value of production factors. In this way, it can talk about Productivity of capital, raw materials and labor. According to definition by Organisation for European Economic Co-operation; (OEEC), Productivity is defined as the ratio of output to one of the factors of production (land, capital, labor and management), according to the definition by European Productivity Agency (EPA), Productivity is the level and intensity of use of each of the factors of production (، www.sanayeonline.com, 2013).

### Malmquist productivity index

This index has been introduced by Fare, Grosskopf, Lindgren, and Ross in 1982-1992, entitled FGLR. Fare defined a proper method for Experimental evaluation of the production function

for several inputs and outputs, using linear planning technique and data envelopment analysis package. The Best Performance border in data envelopment analysis, without a priority for outputs and inputs can be acquired by means of a series of decision making units. Decision making units on efficiency border, are the units with the highest output level and/or the least input level, defined Malmquist productivity index with combining efficiency changes at each unit as well as technology changes.

Malmquist productivity index can be calculated using distance functions and/or other same fucntions:

$$D(X_P, Y_P) = \inf [\theta / (\theta X_P, Y_P) \epsilon PPS] \qquad (1$$

Expression 1 in very specific cases indicates changes at efficiency at ration t+1to t, and cannot be a proper criterion to calculate technology changes. Further, changes of efficiency are ignored in this method. If $D^{k}(X^{k}, Y^{k}) = 1$, then $k^{th}$ unit would be assumed efficient. This function does not specify inefficiency value, Fare analyzed productivity index to two factors regarding inefficiency and linearity of technology border, and the efficiency border is specified using DEA techniques for DMUs. Production function at t and t+1 time to calculate Malmquist productivity index needs resolving four linear planning problems.

$$\begin{aligned} & D^{t}(D_p^t, Y_p^t) = \min\theta \\ & \text{s.t.} \sum_{j=1}^{n} \lambda_j x_{ij}^t \le \theta x_{ip}^t \quad i = 1 \dots \dots m \\ & \sum_{j=1}^{n} \lambda_j y_{rj}^t \ge y_{rp}^t \quad r = 1 \dots \dots s \\ & \lambda_j \ge 0 \quad j = 1 \dots \dots n \end{aligned} \qquad (2)$$

Where $X^{t}_{ip}$ and $y^{t}_{rp}$ is the $i^{th}$ and $r^{th}$ output from $DMU_p$ at t. efficiency value of $Dt (X t , Yt ) = \theta$ indicates to what extent input of $DMU_p$ can be minimized to produce the same output. Instead of t, CCR problem is obtained for t+1, and $D^{t+1}(X^{t+1}, Y^{t+1})$ which is technical efficiency of DMUp at t+1 is obtained. Value of $D^{t+1}(X^{t+1}, Y^{t+1})$ for $DMU_p$ which is distance of $DMU_p$ at t+1 with t border, is obtained using linear planning problem:

$$\begin{aligned} & D^{t}(D_p^{t+1}, Y_p^{t+1}) = \min\theta \\ & \text{s.t.} \sum_{j=1}^{n} \lambda_j x_{ij}^t \le \theta x_{ip}^{t+1} \quad i = 1 \dots \dots m \\ & \sum_{j=1}^{n} \lambda_j y_{rj}^t \ge y_{rp}^{t+1} \quad r = 1 \dots \dots s \\ & \lambda_j \ge 0 \quad j = 1 \dots \dots n \end{aligned} \qquad (3)$$

Similarly, $D^{t+1}(X^{t}, Y^{t})$ is calculated as the distance of $DMU_p$ with t coordinates together with

t+1 efficiency border; to calculate Malmquist productivity index in input nature, it is necessary to take this value as optimal response for linear planning problem.

$$
\begin{aligned}
&D^{t+1}\left(D_p^t, Y_p^t\right) = \min\theta \\
&\text{s.t.} \sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \le \theta x_{ip}^t \quad = 1 \dots \dots m \\
&\sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \ge y_{rp}^t \; r = 1 \dots \dots s \\
&\lambda_j \ge 0 \; j = 1 \dots \dots n
\end{aligned}
\qquad (4)
$$

If assume $D^t(X^t, Y^t)$ and $D^{t+1}(X^{t+1}, Y^{t+1})$ equal to 1 to have efficiency, then the changes of relative efficiency can be defined:

$$
TEC_p = \frac{D_p^{t+1}(X_p^{t+1}, Y_p^{t+1})}{D_p^t(X_p^t, Y_p^t)} \qquad (5)
$$

Malmquist productivity index in input nature for each $DMU_p$ at t and t+1 times is obtained from multiplying efficiency changes by technology changes:

$$
M_p = \sqrt{\frac{D_p^t(X_p^{t+1}, Y_p^{t+1})}{D_p^{t+1}(X_p^t, Y_p^t)} \cdot \frac{D_p^{t+1}(X_p^{t+1}, Y_p^{t+1})}{D_p^{t+1}(X_p^t, Y_p^t)}} \qquad (6)
$$

This value is defined as the combination of convex geometry, because thereby the smallest weak point in efficiency can be specified in this way and the smallest change in each of the efficiencies affects Malmquist productivity index, and one of three cases as follow can emerge then:

- $M_p$>1indicates an increase in productivity and progress can be seen then.
- $M_P$<1 indicates a decrease in productivity and Regress can be seen then.
- $M_P$=1 indicates no change at productivity at t and t+1 time intervals has been appeared.

**Research method**

In this study, Malmquist Total factor productivity index existing at data envelopment analysis package using Input-oriented approach has been used, and DEAP software and WORD software has been used to carry out calculations and organize information, respectively.

**How to extract data and choose decision making units**

In initial, documentary studies for Kerman Khodro, and interviews and meetings with experts in each unit, and organizing meetings with experts and authors, use of their experiences and information in these meetings, how to extract data as well as choosing decision making units, were all specified to carry out the study. Given the data, the courses to carry out this study was chosen and defined. Compliance with observing Privacy of Factory, the information was set in tables and naming automotive was in random, where defining the name of automotive as well as details of factory were avoided.

**Choose the decision making units**

According to existing information, three active units including production entitled decision making units named with DMU1, DMU2 and DMU3 so that the units not affecting production were all removed from decision making units. This study has examined the Kerman motor Assemble saloon.

**Essential research data**

To carry out this study, there was a need to collect and extract production, energy, capital, material and human force data. Further, to calculate essential efficiency and performance, there needed to Equivalent information extraction. The data was extracted as shown in table 1.

**Table 1. Equivalent input and output data**

| Type of data | Title | Definition | equivalent |
|---|---|---|---|
| Input | Materials | Consumables, Spare parts Raw materials | The total cost per dozen Rials |
| | Energy | Electricity , Water , gas , diesel , fuel oil | Per liter of gasoline |
| | Capital | Value of equipment and machinery, The physical Inventory | The total value of capital in terms of ten Rials |
| | Labor | Unskilled and semi-skilled, skilled workforce | Unskilled labor in terms of person |
| Output | Production | Production per unit | Reference vehicle per unit |

**Calculations using software and selection of extractive tables**

After final information in fourteenth time periods was gathered, calculation of MALMQUIST-DEA helped to gather final information using DEAP software-version 2.1 with the assumption of minimizing inputs. It should be noted that selection of VRS/CRS in DEAP ordering file does not affect MALMQUIST-DEA(Timo si ji, et al. 2010).

**The figure for extractive results and their analysis**

The best way to provide report to senior managers is representing results in form of diagram, where the diagram of TFP changes was analyzed to provide better analysis of results, and the factors engaged in these changes were examined. In this study, the results of Kerman motor Assemble saloon have been proposed.

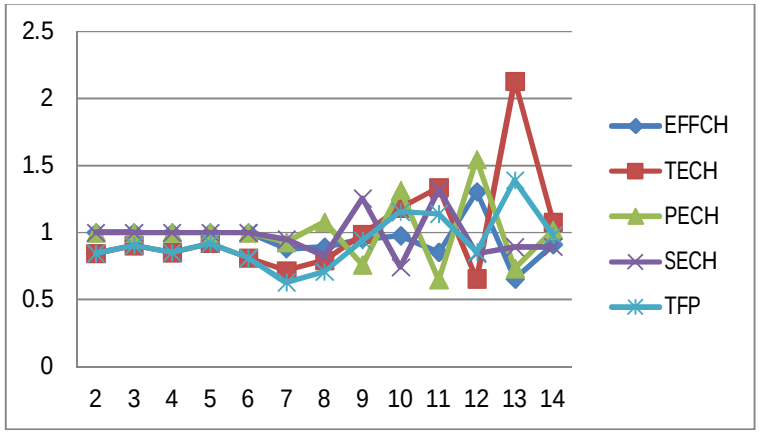


Figure 1. Progress in technical efficiency, technology changes, management efficiency,

Figure 1 indicates the status of technical efficiency, technology changes, management efficiency, efficiency of scale and changes of Malmquist Total factor productivity index at Kerman motor Assemble saloon as follow:

From the early stage of research to sixth period given that stability exists in management efficiency and scales, it is crystal clear that technical efficiency is stable at these periods and any change in productivity index can be influenced of technology changes. Due to a decrease in technology changes, changes in Malmquist Total factor productivity index seen with a big decrease.

Technology changes from the seventh period to later can be obtained by adding new equipment to unit. Further, fluctuations in diagram of technical efficiency, management and scale are influenced of changes at automotive market, exchange market and restriction at importing components.

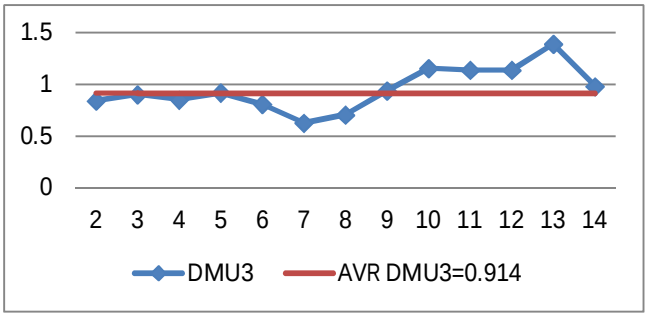


Figure 2. Changes of TFP in a period of study

Information shown in figure 2 indicates changes of productivity in Kerman motor Assemble saloon. This is in a way that the unit would not be without productivity changes so that just a negligible different shown with minimum decrease or increase value.

**Discussion and results**

**The results of analysis of Kerman motor Assemble saloon**

Given the analysis of tables and diagrams, the status of Kerman motor Assemble saloon in mean of these periods is as follows:
-this saloon has not received efficiency in the period of studying stability at changes unless at several specific periods.
-changes of technology primarily are influenced of increasing price of spare tools, equipment and devices to go through maintenance and repair together with adding extra equipment to manufacture new product.
-automotive and exchange market heavily relies on importing components.
-changes at efficiency scale due to necessary agenda are provided to control the inflation in exchange market.

**Research Findings**
In general, it can deduce based on professional findings and interviews, the changes of productivity can be driven from the factors as follow: Aging equipment, Dependence on imports of equipment and spare parts, Lack of easy access from the bureaucracy, Fluctuations in currency and car markets, Energy consumption, sanctions. Furthermore, the results of this study indicate a planning for improvement is needed for second and third units given the decrease.

**Suggestions**
In general, given the results from the research, the suggestions as follows are proposed to improve the existing status and relative performance of automotive industries:
- Need to review old and worn Technology of saloon, Enable research and development unit to reduce dependence on imported parts.
-review Ways of reducing energy consumption per unit of equipment is necessary
-review effect of Changes in the foreign exchange market on automotive and related industries

- If possible, accesses to information, the units of domestic automotive units have to be assessed with foreign automotive units

- Create a comprehensive monitoring system of management information for easy access of managers and researchers to efficient and sustainable planning.

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