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Study of the Relationship between Concentration, Skilled Labor and Efficiency Using the Fuzzy Logic Approach in Iranian Manufacturing Industries

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ABSTRACT: The central goal of this research is to investigate the relationship between concentration ratio, skilled labour and efficiency in Iranian manufacturing industries. In order to measure the technical efficiency, we use the stochastic frontier analysis (SFA) method and data related to 131 of industries at 4-digit level of ISIC code during 1996-2009. To achieve the aim of study, we develop an analytical framework based on the fuzzy logic. Results suggest that there is a positive relationship between efficiency and skilled labour, while the concentration index has negative impact on industry's efficiency.

KEYWORDS: Concentration Index, Skilled Labor, Technical Efficiency, Fuzzy Logic.

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1. INTRODUCTION

According to the statistics from 1988 to 2006, 200 large firms have continuously accounted for about 60 percent of sale and value added of industries. That is, a few firms have had a large part of the market implies that a significant portion of Iranian economic activities have monopolistic structure. During this period, despite emphasize of economic development programs on privatization and increase of competition, it is made no essential change in the structure of Iranian economy. Because, during protracted years the government has dominated on economy and has formed the market situation in interest of state firms and institutions and also via various interferences and governmental allocation of resources and facilities in some markets have contributed to appearance of semi-state or private monopoly (Khodadad Kashi, 2009). Making, simplification and preservation of the competition and setting market structure for transition from this circumstance is effective when we specify the market structure and perform a suitable planning for privatization and combat with monopoly. Market structure, involve an expand spectrum of situation dominant on the market and approaches to the monopoly space proportional to the intensity of deviation from pure competition situation (Shahiki Tash & Nasiri Aghdam, 2011). In order for identification of market structure the structural indicators are generally considered (Khodadad Kashi, 2001). One of the most important structural indicators is concentration (Malekan, 2011) which many researchers use in their empirical works (Khodadad Kashi, 1998:91). This index specifies the share and partial domination of firms and industries on the market (Shahiki Tash, 2003). In other words, in addition to specify the rate of competition or monopoly in the market, analysing this index provides a proper ground for a better understanding of the relationship between market structural and functional elements (Khodadad Kashi, 1998:91), such that the models of Cowling-Waterson (1976), Clark-Davies (1982), Clark-Davies-Waterson (1984), and Kashi (1998) were attempted to investigate the relationship between market structural variables and functional variables based on such an approach. These researchers were showed that the existence of monopolistic/competitive structure causes the appearance of some monopoly/competition- based behaviours and these different behaviors (pricing, research and development, advertising, production, selecting the technology type, barrios to entry and incursion) lead to different economic performance (profitability and returns). In other words, the structure of firms and industries influence their performance. So, study of this relationship is of a high importance because by recognition of the reasons of forming monopolistic power in the markets as well as the reasons of superiority of one or a number of firms or industries, policymakers can diplomatically make decisions about codification of counter-monopoly policies.

On the other hand, achievement to more efficiency would be context of more production. Given the limited resources achievement to more efficiency and production is one of the important goals of any society. The technical efficiency has been defined as acquire the possible maximum production from specific amount of production factors (Karimi, 2002). Technical efficiency may be assessed via the parametric analysis of stochastic frontier or non-parametric method of linear programing. Stochastic frontier analysis has become a well-known instrument in modeling the relationship between input and output quantities and has basically applied for assessing the technical efficiency of firms, provinces, and countries (Kari, 2002). Stochastic frontier analysis was firstly introduced by Ainger et al. (1977), and Meeusen & van den Broeck (1977). The past decade saw a mutation in expansion of parametric methods of assessing technical change, efficiency and productivity using stochastic frontier analysis. In this regard, we may mention the studies of Forsund et al. (1980), Green (1993), and Kumbhakar and Lovell (2000). Other researchers such as Berger and Hannan (1989), Smirlock et al. (1984), Maudos (1998), and Wilson A. Alley (1993) were also shown that the market structure influences the technical efficiency.

The aim of this study is to investigate the relationship between concentration ratio, skilled labor and efficiency in Iranian manufacturing industries. Hence, in this study, we initially measure research variables and then model the impact of these variables on efficiency based on fuzzy logic. Data are collected in the census of Iranian industrial workshops during the period 1996-2009 in a total of 131 four-digit code industries.

2. Literature Review

Market structure is one of the institutional effective factors which its study should be taken into consideration. We review the studies conducted about market structure and performance in Iranian manufacturing industries in two parts of internal and foreign studies.

In a paper entitled "monopoly, competition and concentration in Iranian industrial markets (1988-94)", Khodadad Kashi (2000) have investigated the competition and monopoly in Iranian industrial markets through the channel of concentration indices. In his research, the industries have been separated based on the classification of ISIC 2-digit codes and variables such as sale, employment, and value added have been used. Also, he has calculated the concentration in terms of different indicators such as four-firm concentration ratio, five-firm concentration ratio, and Herfindhal-Hirchman index. His Findings implied that Iranian industrial markets are strictly concentrated and a high share of value added in the industrial sector is belonging to the monopolistic markets. In addition, a few numbers of Iranian industrial plants are dominant on a significant percentage of industrial markets. Calculation of concentration ratio in terms of different indicators has implied that in Iranian industrial sector and specially in the concentrated industries the large firms have tend to use of capital intensive technology.

In a paper entitled "investigating the technical inefficiency in Iranian industry's main subsections (panel data approach)", Farivar (2003) using data of industrial workshops during 1994 to 1999 estimated the stochastic frontier production functions for the industrial sector and its 6 main subsections and calculated the technical inefficiency in each subsections using these functions. The results of estimating stochastic frontier production function using the stochastic effect and via maximizing likelihood logarithm function showed that average technical efficiency in the whole industry level is equal to 0.65. That is, the firms operating in the industry have reached 65% of value added acquirable from used inputs.

Using the stochastic frontier function method, Hakimipour and Kiani (2008) have assessed the technical efficiency and factors affecting it during 1991-2004 for different provinces. Totally, they found that the efficiency of Iranian manufacturing industries has been low and in average has been about 0.37 during the studied period. The provinces of Khozestan and Sistan and Baluchistan have had the highest and lowest efficiency level in industry, respectively. Also, factors such as state ownership of industrial units and intensity of energy consumption have had a negative impact on efficiency. While, with increase of firms size, the efficiency of industries has increased.

Isazadeh and Shaeri (2011) investigated the impact of market structure on efficiency of banking system of Middle East and North African countries during 1995-2008. They firstly computed the efficiency of countries' banking system using the stochastic frontier function and econometrics methods and then, evaluated the effect of market structure on efficiency using the panel data model. The results of estimating cost Trans log function using Bitis-Coli model and stochastic frontier function showed that the existence banking system in MENA countries has an efficiency level of about 80%. The results are also indicative of the negative and significant effect of market concentration on efficiency of banking system in these countries. In other words, with increase of concentration the cost efficiency of banking industry in Middle East and North African countries decreases.

Using the stochastic frontier function, Yosefi et al. (2012) investigated the technical efficiency of Iranian manufacturing industries and recognized the factors affecting their performance during 1996-2007. The results of Betis and Coli (1995) inefficiency effects model indicated that the average technical efficiency of Iranian manufacturing industries during the studied period was about 0.55. Also, survey of factors affecting the efficiency of manufacturing industries showed that despite the increase of energy intensity as well as industries' inefficiency, increasing size of manufacturing industries has not reduced the inefficiency level of industries and state ownership of manufacturing industries has had no impact on their inefficiency level.

Gumbau and Maudos (2000) investigated the relationship between profitability, market structure and efficiency in Spain industry. The results of SFA method reject the hypothesis of collusion in Spain industry, because only in one sector the concentration positively affects the profitability.

In a paper entitled "industrial concentration and competition in Malaysian industry", Bhattacharya (2002) addressed the calculation of concentration and determination of competition in desired industries and analysis of determinant factors in industrial concentration changes for 102 industries of 2-digit code of ISIC during 1986-1996 and using the partial adjustment model and cross sectional analysis and via CR4 concentration index. The results totally are indicative of decrease of concentration level in studied period. Also, the concentration in Malaysian industries is more than other developed countries. The econometrics findings confirmed the significance of the variables of capital intensity, advertising intensity and market size and the theory of concentration dynamics in 10-year period implies a slow and gradual movement of annual adjustment rate of concentration compared to developed countries.

Shaik et al. (2009) investigated the market structure and technical efficiency in American transport industry during 1994-2004. They used SCP approach and SFA method for assessing market structure and technical efficiency, respectively. Their results showed that average stolen properties, average load, debt to total equity, and market structure dramatically influence technical efficiency.

Using SFA method and panel data, Baten et al. (2009) modelled the effects of technical inefficiency in the tea production. They assumed that inefficiency effects are independently distributed as normal distribution and fixed variance, while this is a linear function of observed variables. They found that there is 49% technical inefficiency in the tea production.

From reviewing the studies conducted in desired issue we found that in evaluation of concentration most of them have emphasized on structural indices such as Herfindhal-Hirchman.

3. Theoretical Framework

3.1. Market Structure

The market structure is among issues considered once investigating industries' profitability as well as social costs in microeconomics and industrial economics. This concept covers a wide range of conditions prevailing in the market and approaches to the monopoly space in proportion to the severity of the deviation from the condition of pure competition (Shahiki Tash, 2003). In microeconomics analyses the "pure competition" has always expressed the allocative efficiency as well as maximum social benefits. However, the "monopoly" is known by inefficiencies and incidence of social costs. The reason is attributed to the "market power" of monopolist. The purpose of market power is a condition where the firm can increase its prices without losing the bulk of sales. Of course, market power is not just related to the monopoly situation, but in situations where there is more than one firm in the market there is a possibility of using market power for some of them. In such circumstances, it is said that the market faces "imperfect competition".

3.1.1. Market Structure Measurement

Generally, in the empirical studies the concept of concentration used to judge about the market structure. The concentration is an index for measuring the dominance power of a few firms in a field of activity. The purpose of investigating the market concentration is to determine the type of market in terms of competition, monopoly, strong and weak oligopoly. The general form of concentration indexes is as follows:

$$CI = \sum_{i=1}^{n} S_i W_i$$

Where, CI is the concentration index, S_i is the market share of firm, W_i is the weight related to the share of each firm and n is the total number of firms in the industry. The concentration indexes may be classified based on the methods of weighting the market share of firms. More details about each of the concentration indicators are given in table 2.

Table 1: comparison of the concentration indices and their characteristics

Index	Computational relationship	Index Weight	Main characteristics
Concentration ratio of K Superior firm CR_K	$CR_K = \sum_{i=1}^{K} S_i$	-	1. Simplicity of calculation 2. The limited required information 3. The number of firms in this Index is achieved as follows: $n_e = \frac{K}{CR_K}$ 4. It is a decreasing function of the number of firms in the industry.
HHI	$HHI = \sum_{i=1}^{n} {S_i}^2$ $HHI = \frac{1}{n} + n\sigma^2$ $HHI = \bar{S} + \sum_{i=1}^{n} (S_i - \bar{S})^2$ $HHI = \frac{\zeta_0^2 + 1}{n}$	W_i=S_i	1. It is a measure of the cumulative concentration. 2. Due to the fact that it employ a full information of firms, it often called the index with full information 3. This index gives more weight and importance to large firms. 4. Value of the index decreases with increasing number of firms. 5. The number of firms for HHI Index is calculated as follows: $n_e = \frac{1}{HHI}$

Table 2: Properties of various concentration indices

Index	Range	Parameter	Properties
CR_K	$0 < CR_K \le 1$	No parameter	Only large firms are taken into consideration; the value of K is arbitrary.
HHI	$\frac{1}{n} \le HHI \le 0$	No parameter	All firms are taken into consideration; it is sensitive to the entry of new enterprises.

3.2. Efficiency

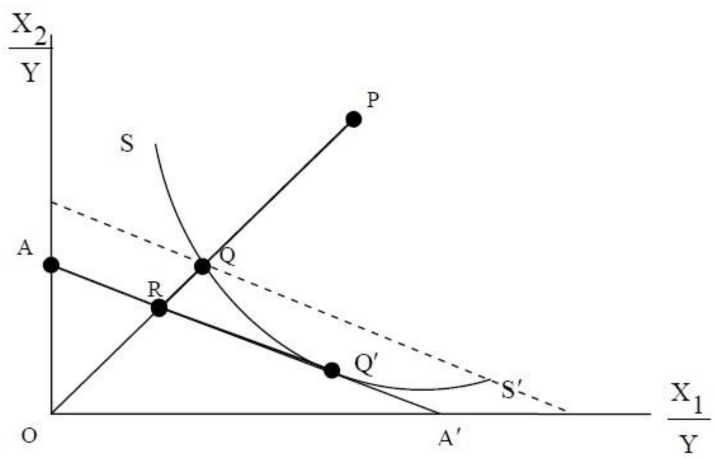
According to the S-C-P approach the efficiency is known as one of the functional variables. This economic concept involves a broad range of economic activities at the level of a firm, industry or in the national economy level. In the theoretical arguments, efficiency is evaluated in four dimensions including technical efficiency, allocative efficiency, economic efficiency, and scale efficiency. Table 3 provides some explanations about these dimensions.

Table 3: Efficiency dimensions and related concepts

Efficiency types	Description
Technical efficiency	Indicates the ability of a firm in maximization of output with respect to specific production factors or, in other words, indicates use of minimum production inputs for producing a given level of output.
Allocative efficiency	Indicates the ability of firms to use the optimal combination of production factors with respect to their prices so that the production cost is minimized.
Economic efficiency	Economic efficiency is a combination of technical efficiency and allocative efficiency. In other words, economic efficiency reflects the efficiency in the manner of production and allocation of production factors. Economic efficiency is also called "cost efficiency' because when a firm acts efficiently in terms of cost, the best allocation and the best production way is also occurred.
Scale efficiency	Access to the MES as the effective efficient point in industries.

Figure (1) provides a comparison between the first three types of efficiency. Suppose that a firm just uses inputs X_1 and X_2 to produce the output y (this definition has been provided under Farrell's (1957) constant returns to scale condition.

Figure 1: comparison of technical efficiency, allocative efficiency and economic efficiency



In the figure (1) SS' curve is assumed to be the firm's isoquant curve the points on which show different combinations of inputs which produce a certain level of output. If the point P is the real situation of firm, its technical efficiency (TE) in this point is:

$$TE = \frac{OQ}{OP}$$

This firm is fully technically efficient when its production is done on the curve SS' (a point like Q). If the production occurs in the right hand side of the curve, the firm will be faced with inefficiency. In a fully efficient firm OQ=OP. The more the distance between OQ and OP, the less is the technical efficiency.

Regarding allocative efficiency it is necessary that the information related to the production factors (i.e. the characteristics of firm's isoquant curve (AA')) be known. In this case the firm's allocative efficiency (AE) in the point P is equal to:

$$AE = \frac{OR}{OQ}$$

The economic efficiency (EE) may be obtained from product of technical efficiency and allocative efficiency.

$$EE = \left\{ \left(\frac{OR}{OQ} \right) \times \left(\frac{OQ}{OP} \right) \right\}$$

3.2.1. Efficiency Measurement Using Maximum Likelihood (ML) Method

One of the best indicators for assessing an industry's performance is evolution of frontier efficiency introduced by Battese and Coelli (1995). According to their model, the relation between inputs (X_{it}) and outputs (Q_{it}) may be estimated using the production function where i stands for firms and t stands for years. So, the production frontier corresponded to the best empirical function is defined as:

$$Q_{it}^F = f(X_{it}, t)$$

Where, Q_{it}^F is potential output level on production frontier in period t for the firm i which is a continuous function, strictly increasing and quasi-concave, and X_{it} is a k-order vector of inputs.

In order to estimate the stochastic frontier the stochastic term $v_{it} - u_{it}$ may be included into the model and the production function can be restated as:

$$Q_{it} = f(X_{it}, t) \exp\{v_{it} - u_{it}\}$$

Where, $v_{it} - u_{it}$ is the combined error term, v_{it} is the stochastic variable indicating the exogenous factors and random shocks and u_{it} is a random variable indicating the endogenous factors and technical inefficiency which is so-called the technical efficiency error. The u_{it} is usually larger than or equal to zero and assumed to be independent from stochastic error. As such, in this study, the technical efficiency of industries is measured using the stochastic frontier function based on Battese and Coelli (1995):

$$Q_{it} = f(x_{it,}\beta)\exp(\varepsilon_{it}) = f(x_{it,}\beta)\exp(v_{it} - u_{it})$$
$$\varepsilon_{it} = v_{it} - u_{it}$$
$$v_{it} \cong iid\ N(o, \sigma_v^2)$$
$$u_{it} \cong iid \left| N(m_{it,}\sigma_u^2) \right|$$
$$u_{it} \geq 0$$

$$m_{it} = m(Z, \delta) = \delta_0 + \sum_{k=1}^{m} \delta_k Z_{k,it}$$

In the above model *f (.)* is the appropriate functional form, y_{it} is the output of i-th unit at time t and x_{it} is the vector of production factors for i-th unit at time t. *Zs* are variables affecting the technical inefficiency of each of the units. δ is a vector of parameters or coefficients corresponded to mentioned variables and the α is the vector of main model parameters which have to be estimated. u_{it} And v_{it} are the amount of inefficiency and other statistical disturbances, respectively. u_{it} Has normal distribution interrupted at zero with a mean of m_{it}. Instead of variances σ_u^2 and σ_v^2, in this model two variance parameters of $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$ are replaced and estimated. Indeed, the parameter γ checks the significance of inefficiency term and its effect on the model. This parameter estimated in the iterative maximization process and takes a value between zero and unit.

In the relation $Q_{it} = f(x_{it,}\beta)\exp(v_{it} - u_{it})$ the amount of inefficiency of each of the firms u_{it}, should be separated from the common disturbance term, v_{it}. For this aim the Jandrow et al. (1982) model is used. Jandrow provide a relation for determining the expected value of u_{it} conditional to the combined disturbance term $E(u_{it}|\varepsilon_i = v_i - u_i)$. If u_{it} has an interrupted normal distribution, this relationship becomes:

$$E(u_{it}|\varepsilon_i = v_i - u_i) = \frac{\sigma\lambda}{(1+\lambda^2)} \left[\frac{\phi\left(\frac{\varepsilon_i \lambda}{\sigma} + \frac{\mu}{\sigma\lambda}\right)}{\Phi\left(-\frac{\varepsilon_i \lambda}{\sigma} - \frac{\mu}{\sigma\lambda}\right)} - \left(\frac{\varepsilon_i \lambda}{\sigma} + \frac{\mu}{\sigma\lambda}\right) \right]$$

With $\lambda = \frac{\sigma_u}{\sigma_v}$ and $\sigma^2 = \sigma_v^2 + \sigma_u^2$; $\lambda = \frac{\sigma_u}{\sigma_v}$ is the degree of asymmetry and non-normality of combined disturbance term, $\varepsilon_i = v_i - u_i$. Also, $\phi(.)$ and $\Phi(.)$ are density function and the standard normal distribution, respectively. We can obtain estimations for u_i and v_i using the maximum likelihood (ML) function and estimations of σ, λ, μ and ε_i from the following function based on the assumptions on the distribution of u_i as well as the estimates of parameters of the model $Q_{it} = f(x_{it,}\beta)\exp(\varepsilon_{it})$.

$$\log l(\alpha,\beta,\mu,\lambda,\sigma_{it}) = \sum_{i=1}^{N}\left\{-\frac{1}{2}\left[T\ln 2\pi - \ln 2 + T\ln\sigma_{it}^2 + \ln(1+\lambda T_i) - 2\ln\phi\left(\frac{\mu}{\sigma_{it}}\right)\right]\right\}$$
$$+\sum_{i=1}^{N}\left\{-\frac{1}{2}\left[-\frac{\lambda}{1+\lambda T}\left(\sum_{i=1}^{T}\frac{\varepsilon_{it}-\mu}{\sigma_{it}}\right)^2 + \sum_{i=1}^{T}\left(\frac{\varepsilon_{it}-\mu}{\sigma_{it}}\right)^2\right]\right\}$$
$$+\sum_{i=1}^{N}\ln\phi\left\{\left[\sqrt{\frac{\lambda}{1+\lambda T}}\right]\left[\frac{1}{\sigma_{it}}\right]\left[\sum_{i=1}^{T}(\varepsilon_{it}-\mu) + T\mu\left(1-\frac{1}{\lambda}\right)\right]\right\}$$

Finally, the amount of technical efficiency of each of the units will be equal to:

$$TE_i = \exp^{-E[u_i|\varepsilon_i]}$$

Given the non-negative value of u_i, one can find out from the above relationship that range of technical efficiency of a firm is a value between zero and one.

3.3. Introducing Skilled Labour

The fourth variable is related to the skilled labor force (human capital) considering the changes in quality of labor force. Most economists believe that investing in human and spending on job training and labor force health increases the quality of labor force and has a positive effect on productivity. Acceptance of human capital as a main component in the economic literature is related to early 1960s, when economists tried to offer a convincing explanation for the substantial portion of economic growth which had remained unexplained.

The main idea in the theory of human capital is based on the fact that investment in human resources leads to increase in peoples' production power and, ultimately, improve economic growth. Of course, historically, investment in human resources leads to increase in economic growth. Smith and the classical economists also emphasized the importance of investing in the skills and expertise of the workforce. Such thoughts caused that in the production function, in addition to labor quantity, the quality of human resources (such as formal education and job training) be also included into the model (Statistical Centre of Iran, 1999).

4. How to Measure Indices

In this section, we present how to measure the concentration coefficient, technical efficiency index and skilled labour coefficient.

4.1. Herfindahl – Hirschman (HHI) Index

Herfindahl – Hirschman (HHI) index is obtained from the sum of squares of market share of all firms in the industry. This index may be measured as follow:

$$HHI = \sum_{i=1}^{K} S_i^2$$

$$S_i = \frac{X_i}{\sum X_i} \qquad i = 1, \ldots, K$$

Where, S_i is the market share of the ith firm obtained from the ratio of firm's output to total output in the market; X_i is the sale of firm i and $\sum x_i$ is total sale of industry's firms.

4.2. Technical Efficiency

In order to assess the technical efficiency, in this study the following trans log function is used:

$$LnQ_{it} = \alpha_0 + \alpha_L LnL_{it} + \alpha_K LnK_{it} + \frac{1}{2}\beta_{LL}(LnL_{it})^2 + \frac{1}{2}\beta_{KK}(LnK_{it})^2 + \beta_{LK}(LnL_{it})(LnK_{it})$$
$$+ \beta_{tL}(LnL_{it})t + \beta_{tK}(LnK_{it})t + \alpha_t t + \frac{1}{2}\beta_{tt}t^2 + (v_{it} - u_{it})$$

With

$$v_{it} \cong iid\ N(o, \sigma_v^2)$$
$$u_{it} \cong iid \left| N(m_{it,} \sigma_u^2) \right|$$
$$u_{it} \geq 0$$

Where, i stands for industry and t is the studied year. Q_{it} Is the industry's value added. The variable L_{it} is the production factors used in the industry. It is notable that the distribution related to "technical inefficiency effects" is a truncation of the nonnegative normal distribution function with components N (m_{it} , σ_u^2). In this study, the technical efficiency level of i-th firm in the year t is obtained based on the estimated Trans log function as the ratio of average production to average potential production as:

$$TE_{it} = \frac{E(Q_{it} / u_{it}, L_{it}, K_{it})}{E(Q_{it}^{F} / L_{it}, K_{it})} = \exp(-u_{it})$$

4.3. Text Coefficient of Skilled Labour

In this research, this index is calculated using the ratio of skilled labour (LL) to total number of labour operating in industry sector (L):

$$LL\_L = \frac{LL}{L} \times 100$$

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5. RESEARCH VARIABLES

Table 2 provides the average values for Herfindahl – Hirschman concentration index separated for 131 industries at 4-digit level of ISIC code during 1996-2009.

Table 4: The index of assessing the market concentration based on the market share of firms in Iranian manufacturing industries

ISIC code	HHI	Group	ISIC code	HHI	Group	ISIC code	HHI	Group
1512	389.44	non- concentrated	2109	413.42	non- concentrated	2913	1571.38	concentrated
1514	762.73	non- concentrated	2111	2228.6	highly concentrated	2914	1592.7	concentrated
1515	202.55	non- concentrated	2212	776.53	non- concentrated	2915	442.80	non- concentrated
1516	371.71	non- concentrated	2219	5075.6	highly concentrated	2919	585.39	non- concentrated
1517	629.84	non- concentrated	2221	1804.4	highly concentrated	2921	3776.6	highly concentrated
1518	2768.8	highly concentrated	2222	6566.2	highly concentrated	2922	548.36	non- concentrated
1519	230.52	non- concentrated	2310	3701.5	highly concentrated	2923	7643.3	highly concentrated
1520	233.03	non- concentrated	2320	1232.01	Concentrated	2924	3943.7	highly concentrated
1531	469.84	non- concentrated	2411	918.89	non- concentrated	2925	501.73	non-concentrated
1532	1365.1	Concentrated	2412	2629.9	highly concentrated	2926	4000.2	highly concentrated
1533	289.40	non- concentrated	2413	1714.5	Concentrated	2929	929.98	non-concentrated
1542	354.26	non- concentrated	2421	1557.9	Concentrated	2930	368.09	non- concentrated
1543	1281.5	Concentrated	2422	246.19	non- concentrated	3000	674.54	non- concentrated
1544	289.40	non- concentrated	2423	240.70	non- concentrated	3110	1627.03	concentrated
1545	213.62	non- concentrated	2424	674.83	non- concentrated	3120	542.64	non- concentrated
1546	563.09	non- concentrated	2429	515.07	non- concentrated	3130	528.92	non- concentrated
1547	5194.08	highly concentrated	2430	3471.1	highly concentrated	3140	3143.6	highly concentrated
1548	274.71	non- concentrated	2511	1355.8	Concentrated	3150	1049.6	concentrated
1551	2019.05	highly concentrated	2519	433.51	non- concentrated	3190	3998.3	highly concentrated
1553	9038.7	highly concentrated	2520	113.13	non- concentrated	3210	1099.8	concentrated
1555	535.87	non- concentrated	2611	628.44	non- concentrated	3220	3073.8	highly concentrated
1556	1240.2	Concentrated	2612	934.31	non- concentrated	3230	1600.1	concentrated
1600	7532.4	highly concentrated	2691	404.89	non- concentrated	3311	476.76	non- concentrated
1711	76.14	non- concentrated	2692	1628.3	Concentrated	3312	5536.5	highly concentrated
1712	1424.1	Concentrated	2694	296.29	non-concentrated	3313	5150.05	highly concentrated
1721	668.67	non- concentrated	2695	102.70	non- concentrated	3320	6021.9	highly concentrated
1723	2748.2	highly concentrated	2696	33.61	non- concentrated	3330	3058.9	highly concentrated
1724	1358.2	Concentrated	2697	62.32	non- concentrated	3410	2089.1	highly concentrated
1725	4635.7	highly concentrated	2698	258.19	non- concentrated	3420	4983.9	highly concentrated
1726	265.27	non- concentrated	2699	83.72	non- concentrated	3430	193.53	non- concentrated
1729	2238.03	highly concentrated	2710	1146.5	Concentrated	3511	4018.54	highly concentrated
1731	881.45	non- concentrated	2721	5194.5	highly concentrated	3512	900.92	non- concentrated
1732	1385.4	Concentrated	2722	1958.8	highly concentrated	3520	637.53	non- concentrated
1810	566.21	non- concentrated	2723	759.30	non- concentrated	3591	316.75	non- concentrated
1911	460.26	non- concentrated	2731	621.97	non- concentrated	3592	2442.9	highly concentrated
1912	2130.02	highly concentrated	2732	2836.6	highly concentrated	3599	5396.78	highly concentrated
1920	441.42	non- concentrated	2811	1221.7	Concentrated	3610	795.40	non- concentrated
2110	3637.03	highly concentrated	2812	664.03	non- concentrated	3691	100	non- concentrated
2021	1020.2	Concentrated	2891	1921.06	highly concentrated	3693	3430.26	highly concentrated
2022	602.76	non- concentrated	2892	1082.3	Concentrated	3694	4430.53	highly concentrated
2023	1445.9	Concentrated	2893	408.79	non- concentrated	3699	484.19	non- concentrated
2029	1467.01	Concentrated	2899	239.24	non- concentrated	3720	2635.8	highly concentrated
2101	1844.5	highly concentrated	2911	4728.4	highly concentrated			
2102	326.63	non- concentrated	2912	377.73	non- concentrated			

Source: research calculation

In a conventional classification of industries according to Herfindahl – Hirschman index, the industries for which the HHI is below 1000 are placed in non-concentrated industries group. The industries in which this index varies from 1000 to 1800 are placed in concentrated industries group, and finally those industries have a HHI over 1800 are placed in highly concentrated industries group. Table 2 suggests that about 50% of industries have an HHI index over 1000 and 50% of industries have an HHI index below 1000. More accurately, 42 of industries are highly concentrated, 23 industries are concentrated, and 65 industries are non-concentrated. This table shows that most of the Iranian manufacturing industries are non-concentrated, such that the industries of "bricks manufacturing", " cutting and shaping and finishing of stone", "preparation and spinning textile fibres", "manufacture of textiles" and "other metallic mineral products not elsewhere classified" have the lowest concentration levels and "Malta and beer manufacturing", "manufacture of metallurgy machinery", "manufacture of tobacco and cigarettes products", "service activities related to printing and manufacture of optical tools" and "the photographic equipment industry" have the highest level of concentration among other manufacturing industries.

Table 3 provides the average technical efficiency scores calculated by the trans log function and using maximum likelihood method. As it mentioned before, the technical efficiency show a firm's ability to maximize the output given the specific amount of factors, or in other words, represents the use of minimum inputs to produce a certain level of output.

Table 5: Average technical efficiency of Iranian manufacturing industries using SFA method

ISIC code	Average efficiency	ISIC code	Average efficiency	ISIC code	Average efficiency	ISIC code	Average efficiency	ISIC code	Average efficiency
1512	0.438393	1724	0.222145	2412	0.473319	2811	0.418948	3210	0.482644
1514	0.619708	1725	0.357127	2413	0.650667	2812	0.394129	3220	0.442914
1515	0.460601	1726	0.376712	2421	0.250605	2891	0.475275	3230	0.617939
1516	0.486953	1729	0.40064	2422	0.501028	2892	0.33838	3311	0.347728
1517	0.394197	1731	0.382108	2423	0.421578	2893	0.359189	3312	0.422738
1518	0.698668	1732	0.364338	2424	0.523077	2899	0.355019	3313	0.413645
1519	0.446224	1810	0.314456	2429	0.447209	2911	0.472557	3320	0.430598
1520	0.548145	1820	0.370498	2430	0.618643	2912	0.383275	3330	0.424008
1531	0.178864	1911	0.489838	2511	0.467782	2913	0.48814	3410	0.665207
1532	0.475268	1912	0.406139	2519	0.366097	2914	0.409839	3420	0.425772
1533	0.643827	1920	0.333944	2520	0.37486	2915	0.370857	3430	0.389074
1542	0.400447	2110	0.329438	2611	0.437825	2919	0.41676	3511	0.346069
1543	0.43972	2021	0.40922	2612	0.363128	2921	0.456404	3512	0.40563
1544	0.400096	2022	0.33491	2691	0.292474	2922	0.357129	3520	0.31616
1545	0.303407	2023	0.385585	2692	0.517215	2923	0.407025	3591	0.515106
1546	0.350661	2029	0.369898	2694	0.395841	2924	0.403852	3592	0.428978
1547	0.326799	2101	0.422614	2695	0.365787	2925	0.374417	3599	0.466051
1548	0.402451	2102	0.517868	2696	0.332035	2926	0.394096	3610	0.335265
1551	0.512352	2109	0.442145	2697	0.208732	2929	0.366522	3691	0.328596
1553	0.568732	2111	0.4241	2698	0.370398	2930	0.418905	3693	0.376503
1555	0.440215	2212	0.261594	2699	0.362335	3000	0.501125	3694	0.384944
1556	0.438702	2219	0.391017	2710	0.498533	3110	0.429128	3699	0.391568
1600	0.43095	2221	0.312109	2721	0.757378	3120	0.391484	3720	0.358585
1711	0.260955	2222	0.303608	2722	0.554244	3130	0.543134		
1712	0.21797	2310	0.410323	2723	0.489446	3140	0.472365		
1721	0.357419	2320	0.574818	2731	0.366278	3150	0.392403		
1723	0.483991	2411	0.542898	2732	0.412326	3190	0.412142		
Total average levels Manufacturing Performance							**0.421173**		

Source: research calculations

According to this table, the average efficiency of studied industries in the period 1996-2009 is at a low level and equal to 0.42. In total, in the studied period, the industries of "dates cleaning, grading and packaging", "manufacture of motor vehicles", " primary form plastics manufacturing; synthetic rubber manufacturing", "prepared animal feeds manufacturing", "vegetable and animal oils and fats manufacturing", "synthetic fibres manufacturing", "manufacture of radio, television and communication equipment and apparatus" have had relatively a higher technical efficiency than other industries.

In contrast, the industries of "manufacture of non-refractory ceramic goods other than for construction", "Textile fiber preparation; textile weaving ", "manufacture of pesticides and other agro-chemical products", "finishing of textiles" and "manufacture of bricks" have had lowest technical efficiency scores. Among these, the industries of "manufacture of copper products" with efficiency score of 0.76 and "grain preparing and grinding" with efficiency score of 0.095 have had highest and lowest technical efficiency, respectively. The average efficiency score of most of the industries (52 industries) has varied between 0.40 and 0.50 and only one industry has had average efficiency level over 0.70.

6. Modelling Using Fuzzy Logic

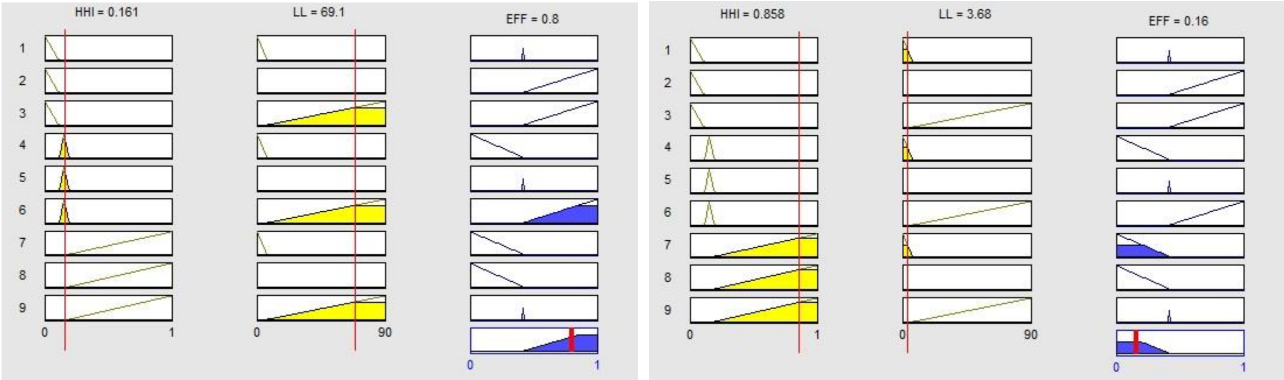
To simulate and measure the efficiency and its relationship with concentration index and skilled labor coefficient we use fuzzy logic tool in MATLAB software. In this study, we simulate the amount of technical efficiency for the studied period using Mamdani model for 2 inputs and 1 output under the rule of *IF- THEN statement*. We perform simulation based on selection of the variable of Herfindahl – Hirschman concentration index (HHI) as the first input at a three levels with the term low for $HHI<M^e$[3], middle for $Me<HHI<X$[4] and high for $HHI>X$ and selection of the variable of skilled labor coefficient (LL_L) as a second input with three statements of low for $LL\_L<M^e$, middle for $M^e<LL\_L<X$ and high for $LL\_L>X$. The triangular membership functions are used to evaluate the relationship among the three variables of concentration index, the coefficient of skilled labor and technical efficiency. Table 6 provides 9 determined fuzzy rule:

Table 6: Status of technical efficiency in Iranian manufacturing industries based on the concentration index and skilled labor

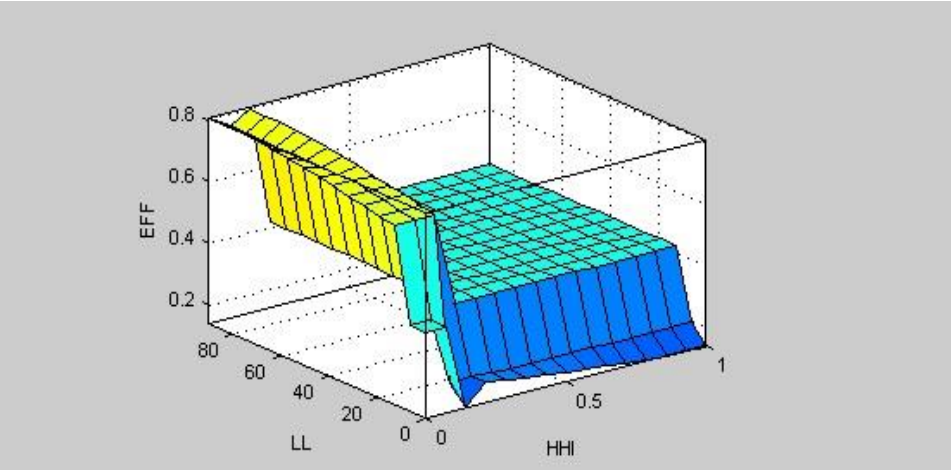
Skilled labor / **Concentration index**	**High**	**Middle**	**Low**
Low	High technical efficiency	High technical efficiency	Unknown (Probably moderate efficiency)
Middle	High technical efficiency	Unknown (Probably moderate efficiency)	Low technical efficiency
High	Unknown (Probably moderate efficiency)	Low technical efficiency	Low technical efficiency

As an example, if the concentration index is low and the skilled labour is high, then the technical efficiency will be high.

[3] median
[4] mean



Graph 1: Output of the technical efficiency using the fuzzy logic and based on concentration index and skilled labor



Graph 2: Technical Efficiency fitted with fuzzy logic in three-dimensional space

According to the output results, the following rules regarding the concentration index, skilled labor and technical efficiency may be derived:

Table 7: The results obtained based on fuzzy logic output on concentration index, skilled labor, and technical efficiency

concentration index		**skilled labor**		**technical efficiency**	
Numerical range [0 1]	**Result**	**Numerical range [0 90]**	**Result**	**Numerical range [0 1]**	**Result**
0-0.1157	Low	0-8.2453	Low	0.4211-0.4183	Medium
0-0.1157	Low	8.2453-8.9308	Medium	0.4183-1	High
0-0.1157	Low	8.9308-90	High	0.4183-1	High
0.1157-0.1961	Medium	0-8.2453	Low	0-0.4211	Low
0.1157-0.1961	Medium	8.2453-8.9308	Medium	0.4211-0.4383	Medium
0.1157-0.1961	Medium	8.9308-90	High	0.4183-1	High
0.1961-1	High	0-8.2453	Low	0-0.4211	Low
0.1961-1	High	8.2453-8.9308	Medium	0-0.4211	Low
0.1961-1	High	8.9308-90	High	0.4211-0.4183	Medium

Source: Research calculation

7. CONCLUSION

In this study, it was attempted to analyze the market structure using Herfindahl – Hirschman concentration index and also to compute and compare the technical efficiency in Iranian manufacturing industries using the stochastic frontier analysis (SFA) and finally to examine the impact of concentration index (a proxy of market structure) and skilled labor on technical efficiency.

Generally, the results of technical efficiency calculation indicated that the average technical efficiency of these industries during 1996-2009 was at a low level and equal to 0.42. The result of this section is consistent with the findings of Hakimipour and Kiani (2008) indicating that the average technical efficiency of Iranian manufacturing industries has been low during the studied period. In investigation of variables affecting the efficiency, the estimation results indicated that the variables of skilled labour and concentration have had a significant effect on technical efficiency of manufacturing industries. Also, the results of investigating the impact of concentration on technical efficiency showed that the efficiency has a negative and significant relationship with concentration- which represents the competition condition of manufacturing industries. In other words, with an increase in the concentration of manufacturing industries, the technical efficiency decreases. In the study of Isazadeh and Shaeri (2011) the impact of concentration on technical efficiency in Iranian manufacturing industries was confirmed. Their findings are also indicative of the existence of a negative significant relationship between concentration index and technical efficiency. The research findings of Bhattacharya (2002) are indicative of decreasing concentration level in studied period. Also, Shaik et al.(2009) show that the market concentration dramatically influences technical efficiency. In addition, there is a positive relationship between skilled labor and technical efficiency; that is, with increase of the number of skilled labor, the technical efficiency increases as well.

Based on this research's findings we can provide the following recommendations:

1. According to the results, the efficiency increases by increase of the skilled labour. So, the main factor affecting the efficiency of manufacturing industries is the skilled labour. Use of the skilled labor, training and holding continuous operational courses according to the methods of effective utilization of manpower to enhance the efficiency is suggested.

2. The results imply that the higher levels of competition in the market increase the efficiency. So, the concentration has a negative effect on technical efficiency. Hence, given the impact of the market structure on efficiency the governments should seek to increase the level of competition in the market which followed by the increased efficiency in manufacturing industries.

3. Finally, increasing efficiency level and use of its resulting benefits, should be considered as a top priority in order to achieve the long-term objectives of economic growth. But this will require a new attitude and approach and a concerted attempt by various governmental and nongovernmental organizations in this field.

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ETHICAL CONSIDERATION

Authenticity of the texts, honesty and fidelity has been observed.

AUTHOR CONTRIBUTIONS

Planning and writing of the manuscript was done by the authors.

CONFLICT OF INTEREST

Author/s confirmed no conflict of interest.

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