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The Productivity and Competitiveness of the Food Manufacturing in Iran

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Abstract: Food manufacturing industry is an important industry in the Iranian economy and has been identified as a thrust area for development. The country has enormous potential in the production and export of various food items due to the abundance of resources and available markets in the world, particularly in the Middle East. In recent years, the government has encouraged the expansion of this industry in an effort to reduce its dependency on oil exports. This paper attempts to analyze trends of technical efficiency, technological change and TFP growth of the food manufacturing industry in Iran. The productivity growth of the 22 food sub-sectors in the Iranian food manufacturing industry from 1997 to 2002 both privately- and publicly-owned was evaluated using the Malmquist Total Factor Productivity (TFP) index. Based of the findings, the paper makes suggestions to be used by policy makers and food processors on various technical issues that can improve productivity and efficiency in Iranian food manufacturing industry.

Key words: Data envelopment analysis (DEA) · Food manufacturing Industry · Malmquist productivity Index and Total Factor Productivity.

INTRODUCTION

Iran, with an area of 1,648 million square kilometers with an estimated population of 71.4 million (2005/06), is situated in the South West of Asia. This country due to its geographic location enjoys a highly diverse climate and rich variety of flora. The 12 types of climate and 12,000 different varieties of flora enable the country to produce a wide range of temperate, subtropical and tropical crops [1]. According to Ministry of Agriculture, Iran has the first to the tenth rank in the universe in the production of 15 products from 25 main garden products; and considering the varieties in producing the garden products, it is in the third rank amongst the world countries after China, America and Turkey with 17 and 16 products respectively [2]. Therefore, food manufacturing Industry is widely recognized as a 'sunrise industry' in Iran having huge potential for uplifting agricultural economy, creation of large scale processed food manufacturing and food chain facilities, generation of employment and export earnings. Moreover, this industry is one of the largest industries in Iran and based on the latest reports [3] it is ranked first in terms of employment in medium enterprise industry, making up 15.1 percent and 13.5 percent in large enterprises industries. in addition, in terms of value added, it also ranked first in medium enterprise industries by around 17 percent and ranked fifth in large enterprise by 10 percent. Regarding these abilities, the government has a specific attention to expand of agro industries as a priority to enhance of non-oil export and self-sufficiency in food products.

The objective of this paper is to evaluate the productivity and competitiveness of food manufacturing industry in the country so that necessary actions can be taken to improve its performance. The TFP analysis is based on the non-parametric approach of DEA and Malmquist index which allows for the decomposition of TFP into three constituent elements for different sources of productivity growth: technological progress (hereafter abbreviated as TECHCH), scale efficiency change (hereafter abbreviated as SECH) and pure efficiency change (hereafter abbreviated as PECH). Data were collected from the Statistical Centre of Iran and they were annual data of 22 four-digit industrial groups (ISIC Rev. 3) based on medium and large sized which made up food manufacturing industry in the country from 1997 to 2002.

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Literature review address us many study in this area. We sited few of them which are more related to the subject. Ephraim[4]estimated the level of technical efficiency for large establishments in selected manufacturing industries in Malawi. The researcher applied the deterministic production frontier approach over 1984 and 1988. He used Data Envelopment Analysis (DEA) for seven manufacturing sectors: tea; tobacco; wearing apparel; printing and publishing; soaps, perfumes and cosmetics; plastic products and fabricated metal products. His results showed that the mean overall technical efficiency ranged from 38 per cent in the printing and publishing industry to 87 per cent in fabricated metal products. However, the minimum technical efficiency scores ranged from as low as 16 per cent in the tea industry to 55 per cent in plastic products at firm level. The predicted firm level efficiencies were explained by firm specific and industry characteristics. The analysis reveals that the market share of the firm is positively associated with technical efficiency while monopoly power is negatively associated with technical efficiency.

Pamela and Cabanda [5] investigated the total factor productivity (TFP) performance of 29 firms in the Philippine food manufacturing industry from 1997 to 2001. They identified the sources of TFP growth and assessed TFP growth changes in a sample of small, medium and large-sized firms and in the industry. Their empirical results suggested that the Philippine food sector featured low productivity growth. Catch-up was the main driver for TFP growth, while poor innovation pulled down the productivity growth. Large-sized firms had the highest TFP growth compared to small and medium-sized firms, which was boosted by its high EFFCH score. However, small and medium-sized firms were more innovative, which contributed largely to their TFP growth. Hence, the determination of sources of TFP growth provided more accurate information for policy implications related to boosting productivity in the food sector. Lastly, they concluded that productivity and efficiency growth were significantly affected by firm size.

Using data of manufacturing survey in Malaysia from 1973-1989, Maisom and Arshad [6] showed that TFP increased each year but its contribution to the manufacturing sector growth was still small. Further in their study, they found that TFP was larger in the foreign-owned firms as compared to the local ones. They concluded that foreign investors had achieved higher benefits from technological progress in Malaysia.

Idris and Ismail [7] analyzed the trend of technical efficiency, technological change and TFP growth in the Malaysian manufacturing sector. The analysis was based on data from the Industrial Manufacturing Survey of 1985 to 2000, collected by the Department of Statistics Malaysia using Data Envelopment Analysis (DEA). Their results showed that during the period under study, TFP growth was increasing and technical efficiency constituted the major contribution to the TFP growth. Further, technological change had shown an increasing trend over time. The industries that experienced high technical efficiency were food, wood, chemical and iron products. The other industry that showed larger technological progress than technical efficiency was textile industry but both values were below unity.

Ali *et al.* [8] evaluated the performance of various segments of food processing industry in India in terms of TFP and efficiency change over a period of 1980/81 to 2001/02. The study empirically analyzed the determinants of productivity change and the reasons for inefficiency in the production process due to an inefficient use of factors of production, which consequently indicated practical policy directions for strengthening and accelerating the growth of various sub-segments of the industry.

Mahadevan [9] used the South Korean Manufacturing Industry data of 1980 - 1994 to estimate the TFP growth of four industries, namely food, textile, chemical and fabricated metal using the SFA technique. She found that the output growth of these four industries was increasingly productivity-driven. The export-oriented industry experienced a higher contribution of TFP growth. Further, her study showed that in light industries (food and textile), the technical efficiency change was negative but in heavy industries, i.e., chemical and fabricated metal, it was positive.

MATERIALS AND METHODS

This study uses data from the census of production collected by the annual Survey of Industries, published by the Statistical Centre of Iran, the Management and Planning Organization (MPO), Government of Iran. In this study, the technical efficiencies of the large and medium establishments were estimated. There were twenty-two 4-digit International Standard Industrial Classification (ISIC) food manufacturing sub-sectors between 1997 and 2002. In this study, due to the availability of data, the concept of firms producing one output (value of products) and five inputs (production labour, non-production labour, fixed capital, raw material and energy) was employed.

The definition of each of these variables is considered as total value of produced products the accounting year (output), production and non-production labours (labour), fixed capital cost, raw material and intermediate input cost that is the major input used in food manufacturing industry such as spices, edible oils, vegetables, chemicals and packing materials etc. and costs of different types of energy namely electricity, diesel and petrol used in food manufacturing units ().

Malmquist TFP index and efficiency scores have been obtained by using the Data Envelopment Analysis Program (DEAP) software (version 2.1) developed by Coelli [10].

Data Envelopment Analysis (DEA): Data Envelopment Analysis (DEA) uses a mathematical programming model to estimate best-practice frontiers without a priori underlying functional form assumption through computing multi-input/multi-output values. Since the first CCR DEA model was put forward by Charnes *et al.* [11], a number of different DEA models and their corresponding real-world applications have appeared in literatures for the relationship between DEA and multiple criteria decision making [15]. DEA can be used to optimize the performance measure of each Decision- making units (DMU). DEA calculates a maximal performance measure for each DMU relative to all DMUs in the firms under observation. In other words, the focus of DEA is on the individual observations as represented by *n* optimizations (where *n* is the number of DMUs), in contrast to the focus on the averages and estimation of parameters that are associated with a single-optimization statistical parametric approach. The major advantage of the DEA approach is that DEA does not require any assumptions about the function form. That means that DEA does not need any priori information on the underlying functional forms and weights among various input and output factors. The performance measure of a multiple inputs and multiple outputs production system can hardly be described by a concrete function form. Therefore, DEA is particularly suitable for analyzing multiple inputs and multiple outputs production systems [11-16].

In measuring the productivity of food manufacturing sector across all sub sectors, the Malmquist TFP index was employed [17]. The TFP can be decomposed into three components to explaining the productivity sources: technical change, pure technical efficiency change and economies of scale and does not require price data. TFP is also capable of accommodating multiple inputs and outputs without worrying about how to aggregate them. Beside TFP does not make any restrictive value/behavior assumptions for the economic units, such as cost minimization, as required by other indexes such as Arcelus and Arozena indexes [18].

The Malmquist Productivity Index: Malmquist [17] and Solow [19] presented the theoretical basis for the Malmquist productivity index and it was used by Caves *et al.* [20] as a method for measuring productivity. Canter and Horst[21], in particular, attempted comprehensive calculations of the Malmquist productivity index by the DEA method at the national, industry and firm level. However, the DEA method, which is the basis for calculating the Malmquist productivity index, has been frequently discussed in the field of operations research and has been used more frequently for analyzing the efficiency of firms in individual industries than for comprehensive empirical analysis.

In this method the Malmquist index is defined using distance functions. Here, an output distance function is used to consider a maximum proportional expansion of the output, given the inputs. More specifically, the Malmquist TFP index measures the TFP growth change between two data points by calculating the ratio of the distances of each data point relative to a common technology.

The output distance function, $d(x, y)$ takes a value of unity if the observed exchange belongs to the frontier output set and takes a value less than one for exchanges operating below the most feasible production set. Define $x = x_{1,\dots,} x_n$ and $y = y_{1,\dots,} y_m$ to be a vector of non-zero inputs and outputs of the $i-th$ exchange in $i-th$ period, respectively. The geometric mean of two productivity indexes is taken to compute the Malmquist index, where the first evaluates productivity under the base technology in period t and the second with respect to period $t+1$ technology. According to some researches, the output-oriented Malmquist index, M between t and $t+1$ is defined as:

$$M(x_{t+1}, y_{t+1}, x_t, y_t) = \left[\frac{d_t(x_{t+1}, y_{t+1})}{d_t(x_{t+1}, y_{t+1})} \times \frac{d_{t+1}(x_{t+1}, y_{t+1})}{d_{t+1}(x_t, y_t)}\right]^{1/2} \quad (1)$$

Equation 2 represents an equivalent way of writing this index:

$$M(x_{t+1}, y_{t+1}, x_t, y_t) = \frac{d_{t+1}(x_{t+1}, y_{t+1})}{d_t(x_t, y_t)}\left[\frac{d_t(x_{t+1}, y_{t+1})}{d_{t+1}(x_{t+1}, y_{t+1})} \times \frac{d_t(x_t, y_t)}{d_{t+1}(x_t, y_t)}\right]^{1/2} \quad (2)$$

The Malmquist index can be decomposed into technical efficiency change and technological change as follows:

$M(x_{t+1}, y_{t+1}, x_t, y_t)$ = Technical Efficiency × Technological Change

The ratio outside the square brackets captures the efficiency change component and the remaining expression in square brackets measures technological change as depicted in Equations 3 and 4, respectively.

$$\text{Technical Efficiency Change} = \frac{d_{t+1}(x_{t+1}, y_{t+1})}{d_t(x_t, y_t)} \quad (3)$$

$$\text{Technological Change} = \left[\frac{d_t(x_{t+1}, y_{t+1})}{d_{t+1}(x_{t+1}, y_{t+1})} \times \frac{d_t(x_t, y_t)}{d_{t+1}(x_t, y_t)} \right]^{1/2} \quad (4)$$

The Malmquist index reveals values greater than unity if improvements in productivity occur. A decline in performance is indicated by a Malmquist index less than one. The same arithmetic holds for each of the components of the Malmquist index. Since the product of the efficiency and technological change defines productivity growth over adjacent time periods, each of these components may show opposite results.

RESULTS AND DISCUSSIONS

This section discusses the performance of all firms from twenty-two sub-sectors which made up the food manufacturing industry in Iran from 1997 to 2002. Specifically, it assesses the sources of TFPCH for the large- and medium-sized firms which are categorized based on the International Standard Industrial Classification (ISIC).

The Data Envelopment Analysis (DEA) approach was used in this study to estimate the changes in the production frontier. Moreover, this study used one output and five inputs, which made it possible to run the output-oriented Malmquist DEA, using the DEAP 2.1. All variables with the exception of labour are expressed in millions of Iranian Rials (RRI). The output-oriented Malmquist productivity index was used to decompose TFPCH (Total Factor Productivity Change) into TECHCH (Technological Change) and EFFCH (Technical Efficiency Change). TECHCH implies shifts in the frontier or innovation while EFFCH implies catching up to the frontier. EFFCH was further decomposed into two components namely pure efficiency change (PECH) and scale efficiency change (SECH), each representing a different source for explaining the EFFCH.

The first component, PECH, characterizes the ability of a particular sub-sector to catch up with the most technical efficient benchmarks, defined by a given production technology, over time. The second component, SECH, indicates the contribution of scale economies to the TFPCH. A change in the scale of production level contributes positively to productivity growth if it involves expansion in the region of increasing returns to scale or contraction in the region of decreasing returns to scale.

This study reveals that the main source of TFP growth for both ownership categories was due to TECHCH (frontier shift effect). In addition, the TFP growth of the medium-sized food manufacturing industry in the private sector was better than that of its large-sized counterpart and that of the public sector as indicated by its TFPCH score which was the highest (10.7 per cent) as indicated in Table and Figure 1.

Table 1: Average TFP Growth, 1997-2002

			Index	%
Industry	Large	Overall Malmquist index (TFPG)	1.069	6.9
		Catching up effect	0.991	-0.9
		Frontier shift effect	1.079	7.9
	Medium	Overall Malmquist index (TFPG)	1.06	6
		Catching up effect	1.018	1.8
		Frontier shift effect	1.041	4.1
Private	Large	Overall Malmquist index (TFPG)	1.069	6.9
		Catching up effect	0.998	-0.2
		Frontier shift effect	1.071	7.1
	Medium	Overall Malmquist index (TFPG)	1.107	10.7
		Catching up effect	1.027	2.7
		Frontier shift effect	1.078	7.8
Public	Large	Overall Malmquist index (TFPG)	1.063	6.3
		Catching up effect	0.972	-2.8
		Frontier shift effect	1.093	9.3
	Medium	Overall Malmquist index (TFPG)	1.056	5.6
		Catching up effect	1.013	1.3
		Frontier shift effect	1.093	9.3

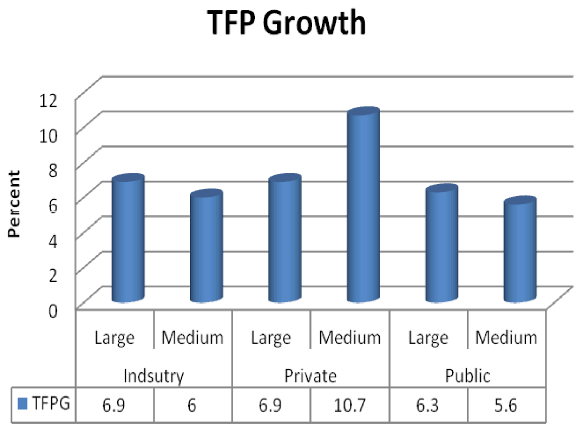

Fig. 1: Average TFP Growth, 1997-2002

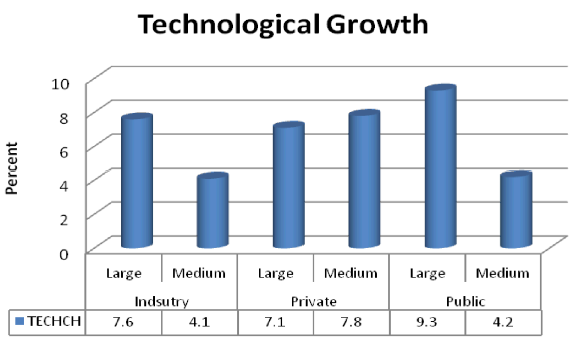

Fig. 2: Average Technological Changes, 1997-2002

Under the entire large-sized food manufacturing industry, 91 per cent of all sub-sectors had a TFPCH score greater than unity while the remaining 9 percent had theirs lower than unity. By comparison, there were only 77 per cent of all sub-sectors from the medium establishments with a TFPCH score greater than unity. Overall, all food industries under both size categories enjoyed a positive growth in TFP.

The average TECHCH scores for almost every sub-sector at the industry level as well as for both private and public sectors suggest that technological progress played a vital role in boosting TFP growth. In other words, it can be fairly said that the food manufacturing firms are very good innovators in advancing their own production technologies. Further, the large-sized food manufacturing industry in the public sector had a higher TFPCH score than its medium-sized counterpart (Figure 2). It was mainly due to the huge government investment for most of the firms under this size category during the period of the second economic development plan in the country. In the private sector on the other hand, it was the medium-sized food manufacturing industry which gained a higher TFPCH score. Meanwhile, on average, there were 14 per cent of all food industries in the private sector which

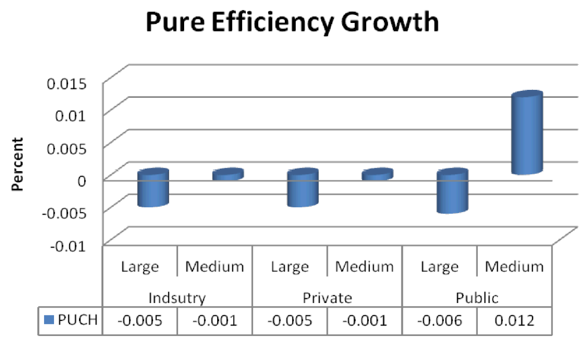

Fig. 3: Average Pure Efficiency Changes, 1997-2002g5

gained no advance in their production technology. The corresponding figure for the public sector was 7.5 per cent.

In terms of the average PECH over time, only the medium-sized firms in the public sector showed an improvement in their technical efficiency, which in turn contributed positively to their respective TFP growth. Further, 65 per cent of all food industries in the public sector exhibited a PECH equal to one whereas the corresponding figure for the private sector was 62.5 per cent. These results indicate that on average, the majority of these industries demonstrated no change in their technical efficiency which brought no impact on their productivity indexes (Figure 3).

The results of the scale efficiency indicate that the highest SECH was 2.8 per cent recorded by the medium-sized food industry in the private sector. Further, there were 50 and 18 per cents of all large- and medium-sized food industries which had a negative growth in scale efficiency, respectively. Meanwhile, based on an ownership category, there was no medium-sized food manufacturing industry with an SECH score less than one in the private sector. By comparison, 29 per cent of all sub-sectors within the large-sized food manufacturing industry in the sector exhibited an SECH score of less than one.

The average target inputs and estimated slack inputs for Iran’s food manufacturing industry indicate that, the major slacks in inputs per unit (as shown in Table 2) were fixed capital use (2036 million Rials) and costs of raw material (499 million Rials), recorded by the large-sized food manufacturing industries which were privately- and publicly-owned, respectively. These led to the high input slacks in the whole food manufacturing industry.

The results of this study reveal several important findings. First of all, there has been an improvement in the competitiveness of food manufacturing industry in the country in terms of total factor productivity. The highest and lowest TFPG are 10.7 and 5.6 per cents, respectively,

Table 2: Average Slacks in Input Uses, 1997-2002

Group	Size	Production labour((NO)	Non production labour (NO)	Fixed capital (RRI)	Energy Cost(RRI)	Intermediate Material (RRI)
Industry	Large	201	13	1916	413	671
	Medium	68	13	1076	281	53
Private	Large	264	45	2036	527	10
	Medium	67	13	435	283	153
Public	Large	54	48	499	121	870
	Medium	8	5	189	33	2

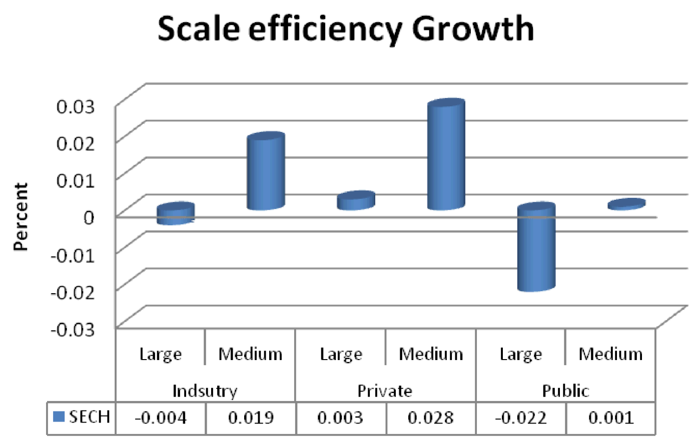

Fig. 4: Average Scale Efficiency Changes, 1997-2002

with the former being for the medium-sized firms in the private sector while the latter being for the medium-sized firms in public sector. Secondly, most of the productivity growth measured is due to technological progress whereas efficiency change is found to exert a relatively small positive effect on the productivity growth. There are a number of food sub-sectors which feature the best technological progresses (frontier shift effects) namely Cleanse, sorting and packaging of pistachio (1518), Processing/preserving of meat and fish (1512), Prepared animal feeds (1533), Vegetable and animal oils and fats (1514), Distilling, rectifying & blending (1551), Slaughter of animal and poultry (1515) and Dairy products (1520).

CONCLUSION

The results of this study reveal several important findings. First of all, there was an improvement in the food manufacturing industry's TFP growth. The highest and lowest TFPCH were 10.7 and 5.6 per cents, respectively, with the former being for the medium-sized firms in the private sector and the latter being for the medium-sized firms in the public sector. Secondly, most of the productivity growth measured for the food manufacturing industry as a whole was due to TECHCH whereas EFFCH was not found to exert a positive effect on productivity growth. On average, technical efficiency scores were estimated to be 0.94 and 0.92 for the large and medium enterprises, respectively. This implies that technical inefficiency could be reduced by 6 and 8 per cents through improvement in scale efficiency and elimination of pure technical inefficiencies, respectively. Thirdly, food manufacturing firms in the country had been scale inefficient due to slacks in production labour, fixed capital and energy use. To overcome this problem, there is a need to work on the optimal levels of input mix and to rationalize the process of acquiring and usage of inputs.

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