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A COMPARATIVE ANALYSIS OF THE EFFICIENCY AND PRODUCTIVITY OF SELECTED FOOD PROCESSING INDUSTRIES IN MALAYSIA

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ABSTRACT

The purpose of this study is to evaluate the performance and change in the technical as well as technological efficiency in the total factor productivity of the 34 food processing industries in Malaysia, and to investigate the changes in their efficiency from 2009 to 2010 by applying two recent methods of data analysis, namely order-m and Malmquist productivity index. The results show that almost all industries have experienced an efficient technological contribution in their respective production functions, but there are wide dissimilarities in the technical efficiency of the organic composition of each industry. Also, there are variations in the change in efficiency scores from 2009 to 2010.

KEYWORDS

Malmquist Productivity Index, Order-m, Technical Efficiency, Technological Efficiency, Total Factor Productivity, Organic composition.

1. INTRODUCTION

Malaysia is a highly open, upper-middle income economy. The food processing industry, along with other industries, plays a vital role in the economy of Malaysia by creating employment, market outlets and adding value to primary agricultural products [1]. Without the proper processing of food, higher productivity of both the industry and the economy in general is, perhaps, unachievable. Moreover, if a country cannot stock its produced food for a long time, the possibilities for exporting are limited to fresh food with the associated higher costs. The more a country is able to efficiently and productively produce a good, the more likely the country will have an absolute and a comparative advantage in the international market. And a country needs comparative advantage to acquire higher gains from trade [2]. This study will focus on efficiency and productivity of the Malaysian food processing industry by applying recent non-parametric approaches to data interpretation.

Though Malaysia has been exporting processed food since 1964, it typically runs a trade deficit in food, although this has declined recently [3]. In 2012, Malaysia exported more than RM 11 billion of food to 200 countries with imports of processed food valued at more than RM 30 billion [4]. In 2015, Malaysia achieved a trade surplus in processed food with exports of approximately RM 18.02 billion, and imports of RM 17.8 billion [5]. Gains from trade have increased from the export of edible products and preparations, cocoa and cocoa preparations, cereals and flour. Its major export destinations were Singapore, Indonesia, USA, Thailand, and Republic of China [4, 5]. To promote growth, the Malaysian Government has launched the National Agricultural Policy (NAP), the Balance of Trade (BOT) Policy, the Industrial Master Plan (for 1986-1995, 1996-2005 and 2006-2020) and the National Agro-Food Policy (2011-2020) [6].

In order to understand and sustain the efficiency and productivity of Malaysian food processing industries for future gains of trade, there is a need for in-depth analysis with sectoral data using recently developed statistical methods. This study is an attempt to illustrate the ranking, efficiency, total factor productivity and overall competitiveness of Malaysian food processing industries. The data is collected by the survey conducted in the study year as the part of post-doctoral study of the corresponding author. Since it is difficult to collect several years' data, the key focus of this study is not only to analyze the data but also demonstrate how recent statistical methods can be used for this type of analysis. The outcome of this research can be applicable to other industries especially at the sectoral level. The article is organized as follows: Section 1 contains the introduction, literature review, research gap or problem and objective of the study; Section 2 discusses the methodology; Section 3 illustrates the data and variables; Section 4 presents results and interpretation of those results and finally Section 5 discuss the conclusion and policy implications of this research.

2. LITERATURE REVIEW

There have been a number of studies on the same or similar topics using conventional approaches to data interpretation. For example, a group scientist investigated the competitiveness and comparative advantage of the Malaysian food processing industry by introducing net social profit (NSP), domestic resource cost (DRC) and the social cost-benefit (SCB) ratio at the production level and Porter's diamond approach at the firm level [7]. They proposed that the industry has comparative advantages at different magnitudes. They found the NSP indices to be quite wide and suggested that there is a need to improve the resource allocation from low to high comparative advantage sectors. Their result also suggested that the food processing industry in Malaysia was gaining competitiveness.

A group researcher has investigated a very similar topic but applied slightly different methods. The main objective of their study was to investigate and measure competitiveness among various producers of food products in Malaysia [2]. Their study involved analysis of quantitative data of 20 food processing industries in Malaysia from the year 2000 to 2008 by implementing financial analysis using net present value (NPV), internal rate of return (IRR), profitability index (PI) and pay-back period (PP), as well as the Policy Analysis Matrix (PAM) model. They found that Malaysia enjoys an above average level of comparative advantage in the production of twenty food products, especially in fish and palm oil, the latter of which has greater comparative advantage than other food production processes because it had the lowest DRC among all products.

The main objective of this study is to comprehend the competitiveness and efficiency of the food processing industry during the initial period of the introduction of various policies which were intended to promote growth of this sector. The key difference between the previous studies and this study is that this study analyses data for the years 2009 and 2010 by applying two contemporary non-parametric methods of analysis (see Note 2 in Appendix), namely the Malmquist productivity index (MPI) and order-m partial frontier analysis. It is believed that the application of these two modern approaches to data interpretation will enable future analysts of similar topics to compare results of the most recent years with those of the initial period more comprehensively, broadly and systematically.

Many previous studies have used MPI analysis and order-m analysis. Some researcher performed an empirical investigation into the regional innovation systems (RIS) which studied the influence of interrelationships among education, knowledge transfer, linkage and communications, regulatory quality, cost of doing business, trade openness, R&D expenditure and high-tech exports in overall economic growth [8]. This paper applied the non-parametric robust partial frontier order-m approach in cross-section data analysis. This enabled the study of behaviors of individual sectors in the course of the overall performance of the economy.

In other hand, study of productivity analysis of ASEAN economies in the transition towards a knowledge-based economy, applied the Malmquist Productivity Index (MPI) analysis [9]. The main purpose of this study was to analyze the nature and extent of productivity changes in Cobb-Douglas production function components and the growth of the knowledge economy of selected ASEAN countries, namely Malaysia, Indonesia, Philippines, Thailand, Singapore plus South Korea. This study used data envelopment analysis (DEA) and MPI analysis to estimate the individual country's efficiency and productivity changes. This aided the analysis of the contribution of technological as well as technical efficiency in the efficiency change of total factor productivity, which is similar to the approach of this study.

A researcher also has use the random coefficient frontier production function to show that input growth is a key factor contributing to output growth in Bangladesh for the period 1981 to 1991 [10]. This empirical study showed that low capital realization lowered the performance of the overall food processing sector despite economic reforms.

The first empirical work separating technical efficiency from technological progress as contributors to total factor productivity was introduced by a group researcher [11]. Technical efficiency is the extent to which firms are able to produce on the "best-practice" production function that specifies the frontier of outputs for all possible input-output combinations. This technical efficiency may be the result of things such as learning by doing, diffusion of new technological knowledge, improved managerial practice, short run adjustment to external shocks and changes in the organic composition of the firm (see Note 1 in Appendix). The extent to which firms are unable to produce on this frontier is referred to as technical inefficiency. On the other hand, technological progress (change, efficiency) is defined as a rise in the best-practice production frontier.

2.1 Research Gaps

Previous studies that have measured productivity and efficiency in the context of the Malaysian food processing industry appear to have left significant research gaps as follows:

1. Very few empirical works have measured total factor productivity and technological change efficiency of the Malaysian food processing industry. Separate investigations of the performance of technological and technical efficiency have also not been found. In addition, a comprehensive analysis of the sectoral contributions of organic composition and technology to total factor productivity is inadequate. These gaps support the application of a precise comparative analysis method for measuring the competitiveness of the industry.

2. The clarification of technical and technological intensiveness for determining the comparative advantage among the industries is also absent in the prior studies.

3. The methodology used in this study can be extended to other industries while measuring total factor productivity, competitiveness and efficiency using up to date methodologies such as MPI and Order m.

2.2 Research Objective

The main purpose of this study is to investigate, in depth, the competitiveness and the performance of the food processing industries in Malaysia by using two new non-parametric methods, namely Malmquist Productivity Index and Order-m analysis. The main reason behind applying these methods is to observe not only the efficiency scores but also the sensitivity of the organic composition and production technology which play significant roles in increasing the total factor productivity of the industries.

3. METHODOLOGY

As stated before, according to the purpose of the study, this study will involve two methods of data analysis for the decision making, namely Malmquist Productivity Index (MPI) analysis and Order-m Partial Frontier approach.

3.1 Malmquist Productivity Index (MPI)

The Malmquist Productivity Index is a bilateral index that can be used to compare the production technology of two or more economies or sectors. It was developed by Sten Malmquist. This method will be used because it has a number of desirable features suitable for this study. First, Malmquist indexes are unit independent and they do not require input or output prices in their construction. Second, the computation is relatively straightforward, as demonstrated by some researcher [12]. Third, the MPI can accommodate multiple inputs and outputs without having to aggregate them. Fourth, MPI has two components – technical efficiency change and technological change [12]. Technical efficiency refers to the ability to use a minimal amount of input to produce a given level of output. On the other hand, technological efficiency means the ability to combine the inputs most efficiently in order to produce the maximum level of output. Over time, the level of the output of an industry will increase due to technological changes that affect the ability to optimally combine inputs and outputs. Thus, for any organization in an industry, productivity improvements over time may be either technical efficiency improvements (catching up with their own frontier) or technological improvements (because the frontier is shifting up over time), or both [13].

A study has shown that productivity and efficiency are the indexes of competitiveness [14]. Another studies also stated that productivity and efficiency are the most reliable measurest of competitiveness [15]. The importance of analyzing these two components is that it provides insight into the sources of change in total factor productivity. The fifth desirable feature is that the original MPI assumes constant returns to scale for the production process. As a result, if the production process displays decreasing returns to scale the original MPI typically overestimates productivity change or underestimates it for increasing returns to scale. A group researcher recommended the use of a generalized MPI, to cope with the issue of variable returns to scale, that includes an additional component, called scale index, to represent the effect of economies of scale on productivity [12]. Scale efficiency refers to the extent an organization can take advantage of returns to scale by altering its size towards optimal scale. A researcher also echoed that MPI does have the accuracy in measuring the productivity change under an appropriate characterization of the technology [16]. Sixth, the Malmquist DEA approach measures efficiency for one year, relative to the prior year, while allowing the efficiency frontier to shift. So positive total factor productivity growth is indicated by a value greater than unity, whereas a value less than unity indicates productivity decline.

There are two approaches to measuring productivity by using the Malmquist productivity index. One is the output-oriented Malmquist productivity index which is the way to measure a change in productivity to see how much more output has been produced, using a given input level and the present state of technology, relative to what could be produced under a given reference technology using the same input level. Another is input-oriented Malmquist productivity index which is the way to measure the change in productivity by examining the reduction in input use that is feasible given the need to produce a given level of output under a reference technology [17]. This study concentrates on the output-oriented Malmquist productivity index for analysis.

The functional definition of DEA MPI is as follows:

$$M^{t+1}(X^{t+1}, y^{t+1}, X^{t}, y^{t}) = [\frac{D^{t}(x^{t+1},y^{t+1})}{D^{t}(x^{t},y^{t})}\frac{D^{t+1}(x^{t+1},y^{t+1})}{D^{t+1}(x^{t},y^{t})}]^{\frac{1}{2}} \quad (1)$$

Where D^t is a distance function measuring the efficiency of conversion of inputs x^t to outputs y^t in the period t. DEA efficiency is considered a distance measure in the literature as it reflects the efficiency of input/output conversion of DMUs. In fact, if there is a change in technology the following year which is (t+1), then $D^{t+1}(x^t, y^t)$ will be the efficiency of altering input in period t to output in period t $\neq D^t(x^t, y^t)$. Hence, it can be said that technically Malmquist Productivity Index (MPI) is a geometric average of the efficiency and technological changes in the the two referenced periods and it is thus can be written as:

$$M^{t+1}(X^{t+1}, y^{t+1}, X^t, y^t) = [\frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)}][\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)}]^{\frac{1}{2}} \quad (2)$$

or, M = ET

where M stands for productivity index, E is the technical efficiency change and T is the technology change. E measures the change in the CRS technical efficiency of period t+1 over that in period t. If E is greater than 1, It is assumed that there is an increase in the technical efficiency. However, T represents the average technological change over the two referred periods.

3.2 Order-m Frontier Approach

The study discusses order-m frontier in a non-technical way for easier access to a broader audience. In contrast to the FDH or DEA approach, the idea behind the order-m approach is to compare one sector's performance with a randomly drawn sub-sample of sectors' performance instead of evaluating one sector with respect to the performance of all other sectors [18]. The researcher has to specify the sub-sample size, which is denoted as m, giving the name to the procedure. For instance, this study worked over 34 observations; therefore, the m can be 5, 10, 15, 20, 25, 30 etc. For simplicity, the study took m = 20 and m = 25 for partial frontier and m = 34 for full frontier analysis. Afzal applied the nonparametric robust partial frontier order-m approach to determine the frontier region in his study [8]. The evaluation of sectors' individual performances is done in an identical style to that of the DEA or FDH approach based on partial frontiers. The order-m performance measure contains most of the characteristics of the FDH or DEA model. In addition, it is less sensitive to outliers and noise in the data as the partial frontier is not enveloping all observations [18].

The primary idea of the unconditional *order-m* is straightforward. For instance, in a multivariate case, consider (x_0, y_0) as the inputs and outputs of the unit of interest. (X_1, Y_1), ..., (X_m, Y_m) are the inputs and outputs of m randomly drawn units that satisfy $X_i \leq x_0$. $\lambda_m(x_0, y_o)$ measures the difference between point y_0 and the order-m frontier of Y_1,......, Y_m. This can be written as:

$$\lambda_m(X_0, y_0) = max_{(i=1...m)}\{min_{j=1...q}(\frac{Y_i^j}{yj})\} \quad (3)$$

With $Y_i^j(y^j)$ with the j^{th} component of Y_i(of y_0 respectively) the order-m efficiency measure of unit (x_0, y_0) is defined as:

$$\lambda_m(X_0, y_0) = E[\lambda_m(X_0, y_0) \updownarrow X \leq x_0] \quad (4)$$

The obtained performance measures the radial distance of the unit to the order-m frontier. Note that in any case, a unit is at least compared to itself which results in a performance score of one. For an extensive treatment of the conditional and unconditional order-m approach see [19, 20].

4. DATA AND VARIABLES

Table 1 shows the summary of different numerical indicators used as input and output variables. This study used Cost of Input, Total Employment, Salaries & Wages Paid, Value of Assets Owned, and Number of Establishments as input variables. This study also applied Value of Gross Output and Value-Added as the output variables. For all the variables, the 2009 and 2010 data has been collected and analyzed for 34 food processing industries operating in Malaysia. Due to a lack of panel data for recent years, this study has used this data set to investigate the initial stage of policies implemented by the Malaysian government during 2009-2010. The data were collected from the Department of Statistics, Malaysia and annual report of food industry in Malaysia.

Table 1: Summary of the indicators used as variables:

Type	Indicator	Unit
Output Variables	Value of gross output	RM'000
	Value added	RM'000
Input Variables	Cost of input	RM'000
	Total employments	No.s
	Salaries & wages paid	RM'000
	Value of assets owned	RM'000
	No. of establishments	No.s

5. RESULTS DISCUSSION

5.1 Malmquist Summary Index Analysis

Table 2 shows the descriptive summary of the results obtained from the MPI index analysis. In the MPI analysis, any efficiency scores greater than unity mean an increase in efficiency, and any efficiency scores less than unity means declines in efficiency. The result shows some significant outcomes which need to be evaluated. Almost all the industries show a negative change in the technical efficiency except for Manufacturer of Palm Kernel Oil and Manufacturer of Glucose & Glucose Syrup, Maltose. On the other hand, all the industries show a positive change in the technological efficiency which outweighs the changes in technical efficiency. As a result, almost all the industries show positive changes in the efficiency of total factor productivity. Five industries show a negative change in the efficiency of total factor productivity, namely Manufacturer of Coconut Oil, Manufacturer of Flour Milling, Manufacturer of Tea, Manufacturer of Sauces including Flavoring Extracts such as Monosodium Glutamate, Manufacturer of Other Food Products. The cause of this decline is a negative change in the technical efficiency of these industries that outweighs the positive change in technological efficiency. The data show that from 2009 to 2010 the value-added by these industries has increased, but employment and average salary have also increased. Hence, there is a decline in efficiency.

It is evident from the results obtained that the highest performing industry is Manufacturer of Kernel Palm Oil with a score of 4.147 in the efficiency change of TFP, which indicates an approximate 314.7% increase in the industry's overall efficiency, indicating increasing returns-to-scale in the industry's production function. About 1.4% of this change is due to growth in technical efficiency and 309% of this change is due to growth in technological efficiency. Hence, the result suggests that although the contribution of capital and labor to production has increased somewhat; on the other hand, the contribution of technology has increased significantly over the last few years. The second highest performing industry is Manufacturer of Glucose & Glucose Syrup, Maltose. This industry shows no change in the technical efficiency but a score of 3.939 in the change in the technological efficiency, which means about 293.9% increase in the efficiency of total factor productivity caused solely by the increase in technological efficiency. Since technological efficiency increases are likely the result of developments external to the industry itself, this suggests that there is still scope for improvement in the organic composition of both these high performing industries.

The industry with the highest decline in the change of total factor productivity is Manufacturer of other Food Products, with an approximate 45.7% decrease and a score of 0.162 in the change of technical efficiency, which means about an 83.8% decline in the technical efficiency. The technological efficiency has increased by about 234.7%, therefore the decline can be attributed to the negative change in the technical efficiency. The second highest decline in the change in the efficiency of total factor productivity is attained by Flour Milling industry, which has about a 39.5% decrease in the efficiency of total factor productivity. The approximate 271.7% increase in technological efficiency could not compensate for the 83.7% decrease in technical efficiency, hence the decline. In fact, this is evident in almost all industries where there is a decline in the change of efficiency of total factor productivity: the increase in the technological efficiency could not offset the decrease in technical efficiency. Therefore, it might be said that these industries are more sensitive to their organic composition rather than to their production technology. This suggests that there is still much scope to further investigate the industry-wide sensitiveness to the organic composition as well as technology using more rigorous data, which will help policy makers to take appropriate and necessary steps to boost the food processing industries in Malaysia. Figure 1 shows a comparative visualization of all the factors' efficiency changes by indicating industries in the horizontal axis and change in efficiencies of technical, technological and TFP in vertical axis.

Table 2: Summary of the results obtained from the MPI Analysis

DMU	Industry Name	Change in Technical Efficiency	% Change in Technical Efficiency	Change in Technological Efficiency	% Change in Technological Efficiency	Change in TFP Efficiency	% Change in TFP Efficiency
1	Manufacturer of meat & meat products	0.218	-78.2	6.461	546.1	1.41	41
2	Manufacturer of poultry & poultry products	0.511	-48.9	4.444	344.4	2.269	126.9
3	Manufacturer of fish & fish products	0.266	-73.4	6.956	595.6	1.849	84.9
4	Canning & preservation of other fruits & vegetables	0.236	-76.4	6.392	539.2	1.509	50.9
5	Pineapple canning	0.331	-66.9	7.352	635.2	2.432	143.2
6	Manufacturer of nut & nut products	0.258	-74.2	6.319	531.9	1.632	63.2
7	Manufacturer of crude palm oil	0.358	-64.2	5.457	445.7	1.951	95.1
8	Manufacturer of refined palm oil	0.387	-61.3	4.196	319.6	1.625	62.5
9	Manufacturer of palm kernel oil	1.014	1.4	4.09	309	4.147	314.7
10	Manufacturer of other vegetable and animal oils & fats	0.554	-44.6	3.9	290	2.16	116
11	Manufacturer of coconut oil	0.198	-80.2	4.677	367.7	0.925	-7.5
12	Manufacturer of ice cream	0.171	-82.9	6.056	505.6	1.034	3.4
13	Manufacturer of condensed, powdered and evaporated milk	0.404	-59.6	3.339	233.9	1.349	34.9
14	Rice milling	0.397	-60.3	3.716	271.6	1.474	47.4
15	Flour milling	0.163	-83.7	3.717	271.7	0.605	-39.5
16	Manufacturer of other flour/grain mill products	0.466	-53.4	4.534	353.4	2.111	111.1
17	Manufacturer of glucose, glucose syrup & maltose	1	0	3.939	293.9	3.939	293.9
18	Manufacturer of sago & tapioca flour products	0.483	-51.7	5.067	406.7	2.448	144.8
19	Manufacturer of biscuits and cookies	0.258	-74.2	4.831	383.1	1.244	24.4
20	Manufacturer of bread, cake and other bakery products	0.225	-77.5	4.725	372.5	1.064	6.4
21	Manufacturer of snacks, crackers & chips (e.g. prawn/fish crackers, potato/banana/tapioca chips)	0.284	-71.6	4.625	362.5	1.314	31.4
22	Manufacturer of sugar	0.449	-55.1	2.587	158.7	1.162	16.2
23	Manufacturer of cocoa products	0.59	-41	2.536	153.6	1.496	49.6
24	Manufacturer of chocolate products & sugar confectionery	0.233	-76.7	3.892	289.2	0.907	-9.3
25	Manufacturer of macaroni, noodles & similar products	0.232	-76.8	4.208	320.8	0.978	-2.2
26	Manufacturer of coffee	0.214	-78.6	4.075	307.5	0.874	-12.6
27	Manufacturer of tea	0.233	-76.7	3.36	236	0.783	-21.7
28	Manufacturer of sauces including flavoring extracts such as monosodium glutamate	0.191	-80.9	4.006	300.6	0.764	-23.6
29	Manufacturer of spices & curry powder	0.226	-77.4	3.764	276.4	0.849	-15.1
30	Manufacturer of other food products	0.162	-83.8	3.347	234.7	0.543	-45.7
31	Distilling, rectifying and blending of spirits; ethyl alcohol production from fermented materials	0.503	-49.7	2.297	129.7	1.156	15.6
32	Manufacturer of wines, malt liquors & malt	0.596	-40.4	2.156	115.6	1.285	28.5
33	Manufacturer of soft drinks	0.323	-67.7	2.126	112.6	0.688	-31.2
34	Production of mineral water	0.316	-68.4	3.658	265.8	1.155	15.5

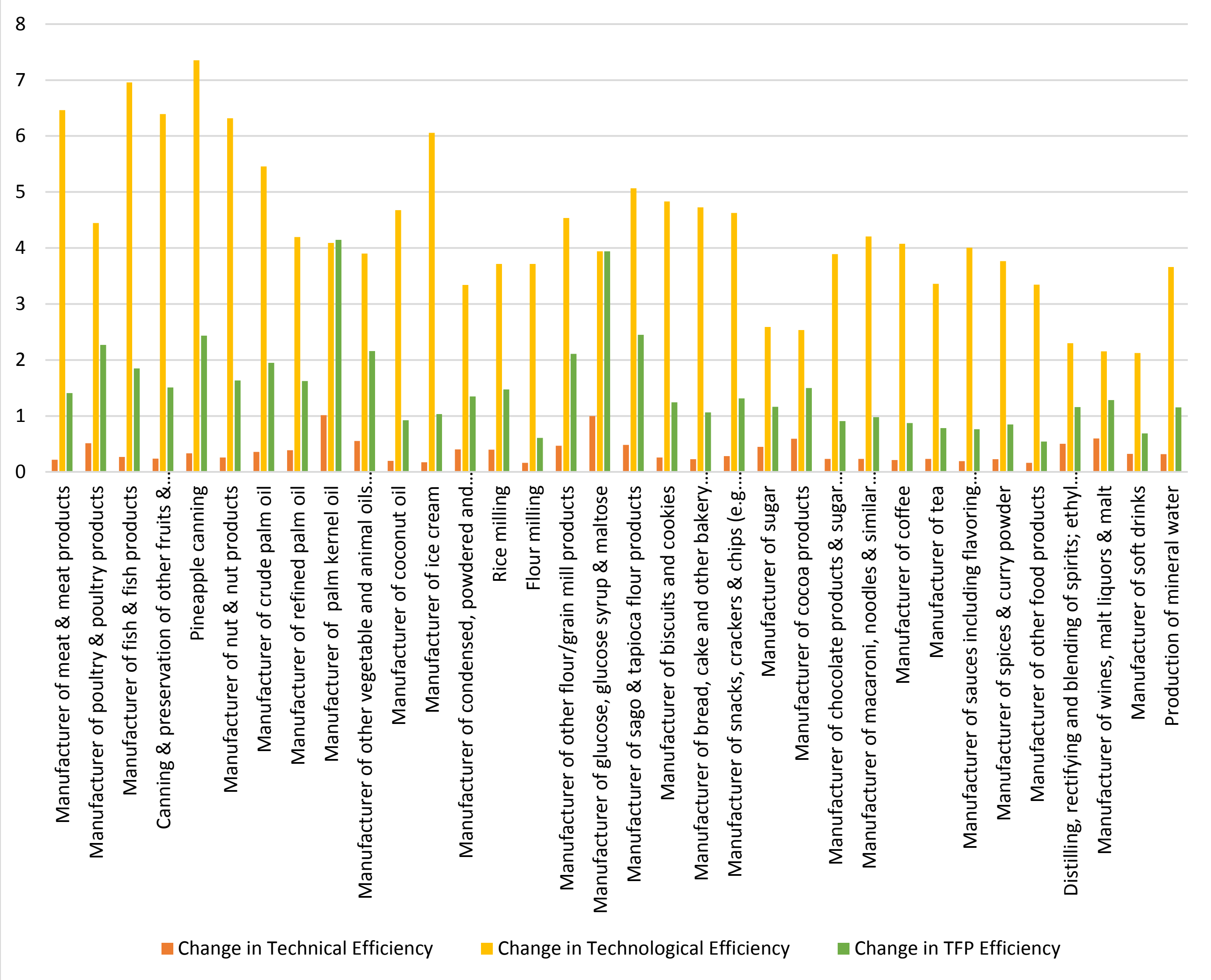

Figure 1: Comparative visualization of the MPI analysis (Source: Author calculation)

5.2 Order-m Analysis

Tables 3 & 4 report the results obtained from the order-m analysis for the years 2009 and 2010 respectively. As stated before, the study has taken m = 20 and m = 25 for partial frontier and m = 34 for full frontier analysis. The comparative efficiency performance of each industry in the years 2009 and 2010 are shown in Figures 2 and 3 respectively. Figure 4 shows the percentage increase or decrease in the efficiency score for the partial frontiers and the full frontier separately for each industry. By taking a closer look at those figures, it can be seen that for both the years the partial frontier analysis for m = 20 and m = 25 show almost similar results, but they vary to a significant extent with that of full frontier results. In the partial frontier analysis, the best performing industry is the Manufacturer of Crude Palm Oil for both m = 20 and m = 25 in both the years. The Manufacturer of Palm Kernel Oil shows a significant rise in the efficiency score over the one-year period, ranking 4th in 2010 from 10th in 2009, with an almost 29% increase in the efficiency score. The poorest performing industry is the Manufacturer of Wine Liquor and Malt for both partial frontiers in both years, also having the highest decline in the efficiency score from 2009 to 2010.

The full frontier order-m analysis for the years 2009 and 2010 shows that the best performing industries for both the years are the Manufacturer of Crude Palm Oil, Manufacturer of Refined Palm Oil, Manufacturer of Palm Kernel Oil, Manufacturer of Other Vegetables and Animal Oils and Fats, Manufacturer of Condensed Powdered and Evaporated Milk, Manufacturer of Bread Cake and Other Bakery Products, Manufacturer of Sugar, Manufacturer of Cocoa Products, and Manufacturer of Wines Malt Liquors and Malt, all having an efficiency score of 1 in both the years. The highest scorer in the order-m analysis is Manufacturer of Coconut Oil, with an efficiency score of 2.953242 in the year 2009 and 2.829483 in the year 2010, which is an approximate 4.19% decrease over the one-year period. The outcome indicates that this industry is performing well and the mechanism of its production process is working efficiently, although it is exhibiting significantly high diminishing returns-to-scale in its production.

The lowest performing industry is the Manufacturer of Biscuits and Cookies with an efficiency score of 0.7177833 in the year 2009 and 0.716358 in the year 2010, which is about a 0.20% decrease over the one-year period. The MPI analysis also shows that this industry has a decline of 74.2% in its technical efficiency. This means there is scope to improve its production process and its organic composition, and since it exhibits increasing returns-to-scale in its production process, the improvement can further secure its future sustainability. The analysis suggests that this industry should follow the mechanism of Manufacturer of Wines Malt Liquors and Malt as pseudo reference (see Note 3 in Appendix); in an attempt to eventually reach an efficient point of production.

By analyzing these results, it can be seen that the highest increase in the efficiency score from 2009 to 2010 is held by Pineapple Canning industry. It shows about a 4.78% increase in its efficiency score. This is because although the amount of value-added by the industry fell, so did the amount of input cost including salaries and wages paid to employees. As a result, overall efficiency has increased. On the other hand, the highest decline in the efficiency score is exhibited by the Manufacturer of Tea which is approximately a 14.67% decrease. Data suggests that this is because the increase in the industry's value-added could not offset the increase in the cost of salaries and wages paid to the employees. Twelve industries among the 38-show constant efficiency score over the one-year period. Figures 2 and 3 show the relative performance of all the industries for the years 2009 and 2010 respectively. Figure 4 shows the comparative percentage increase or decrease in the efficiency score from 2009 to 2010 for each industry

Table 3: Summary of the results from Order-m Analysis for 2009

DMU	Industry name	Efficiency Score			Efficiency Rank			Pseudo Reference		
		m=34	m=20	m=25	m=34	m=20	m=25	m=34	m=20	m=25
1	meat & meat products	1.18675	0.98629	0.99314	10	27	26	35	1	1
2	poultry & poultry products	0.99875	0.78942	0.81300	30	10	8	25	2	2
3	fish & fish products	1.16684	0.93207	0.96290	12	21	21	3	3	3
5	Canning & preservation of other fruits & vegetables	1.42727	0.95240	0.97532	8	22	22	5	5	5
6	Pineapple canning	1.87641	1.00000	1.00000	2	31	31	6	6	6
7	nut & nut products	1.16768	0.98710	0.98710	11	28	24	35	7	7
8	crude palm oil	1.00000	0.47320	0.54399	21	1	1	8	9	9
9	refined palm oil	1.00000	0.54529	0.62989	22	2	2	9	10	10
10	palm kernel oil	1.00000	0.61865	0.65793	23	4	5	10	21	21
11	other vegetable and animal oils & fats	1.00000	0.74370	0.74119	24	6	7	11	11	11
13	coconut oil	2.95324	1.00000	1.00000	1	30	30	13	13	13
14	ice cream	1.19627	0.95875	1.00000	9	23	28	14	14	14
15	condensed, powdered and evaporated milk	1.00000	0.57664	0.64032	25	3	3	15	23	23
16	Rice milling	1.00032	0.77132	0.84016	20	9	12	16	4	16
17	Flour milling	1.01140	0.74909	0.81308	19	7	9	17	17	17
18	other flour/grain mill products	1.54955	0.99816	1.00000	6	29	29	18	18	18
19	glucose, glucose syrup & maltose	1.85644	1.00000	1.00000	3	32	32	19	19	19
20	sago & tapioca flour products	1.46275	1.00000	1.00000	7	33	33	18	20	20
22	biscuits and cookies	0.71778	0.87095	0.92173	34	16	17	36	24	22
23	bread, cake and other bakery products	1.00000	0.64508	0.71412	26	5	6	23	23	23
24	snacks, crackers & chips (e.g. prawn/fish crackers, potato/banana/tapioca chips)	0.78006	0.84085	0.90803	33	12	16	36	24	24
25	sugar	1.00000	0.97580	0.99189	27	25	25	25	25	25
26	cocoa products	1.00000	0.85718	0.88342	28	15	13	26	26	26
27	chocolate products & sugar confectionery	1.08364	0.92272	0.94954	15	20	20	36	29	27
29	macaroni, noodles & similar products	1.01783	0.80774	0.82757	18	11	10	29	29	29
30	coffee	1.02361	0.85281	0.89763	16	14	14	30	30	30
31	tea	1.66428	0.97441	0.99574	5	24	27	31	31	31
32	sauces including flavoring extracts	1.02265	0.89106	0.93381	17	18	18	32	29	29
33	spices & curry powder	1.15241	0.87930	0.89926	13	17	15	33	33	33
34	other food products	0.93949	0.90388	0.93614	32	19	19	36	30	34
35	spirits; ethyl alcohol production from fermented materials	1.78884	0.98166	0.98229	4	26	23	35	35	35
36	wines, malt liquors & malt	1.00000	1.30997	1.34112	29	34	34	36	24	24
37	soft drinks	0.99524	0.75664	0.83640	31	8	11	25	16	37
38	mineral water	1.09309	0.84824	0.87893	14	13	4	38	38	38

Table 4: Summary of the results from Order-m Analysis for 2010

DMU	Industry name	Efficiency Score			Efficiency Rank			Pseudo Reference		
		m=34	m=20	m=25	m=34	m=20	m=25	m=34	m=20	m=25
1	meat & meat products	1.12451	0.97153	0.98686	15	26	27	31	1	1
2	poultry & poultry products	0.99873	0.79522	0.83284	34	9	8	25	2	2
3	fish & fish products	1.20719	0.90412	0.92492	10	19	18	3	3	3
4	Canning & preservation of other fruits & vegetables	1.47776	0.95020	0.98343	5	24	25	5	5	5
5	Pineapple canning	1.96614	1.00000	1.00000	2	30	30	6	6	6
6	nut & nut products	1.13087	0.97149	0.98931	13	25	28	31	7	7
7	crude palm oil	1.00000	0.46353	0.49417	24	1	1	8	33	33
8	refined palm oil	1.00000	0.48387	0.52704	24	2	2	9	10	10
9	palm kernel oil	1.00000	0.79991	0.84694	24	10	10	10	15	15
10	other vegetable and animal oils & fats	1.00000	0.77956	0.88556	24	7	14	11	11	11
11	coconut oil	2.82948	0.98814	1.00000	1	29	29	13	13	13

12	ice cream	1.20044	0.93696	0.97652	11	22	23	14	14	14
13	condensed, powdered and evaporated milk	1.00000	0.69041	0.78375	24	4	4	15	33	33
14	Rice milling	1.00221	0.80411	0.80235	23	11	6	16	16	16
15	Flour milling	1.00884	0.82144	0.85638	22	13	12	17	22	17
16	other flour/grain mill products	1.38898	1.00000	1.00000	7	32	32	7	18	18
17	glucose, glucose syrup & maltose	1.86053	1.00000	1.00000	3	31	31	13	19	19
18	sago & tapioca flour products	1.30239	1.00000	1.00000	9	33	33	18	20	20
19	biscuits and cookies	0.71636	0.84478	0.89773	38	14	16	32	22	22
20	bread, cake and other bakery products	1.00000	0.62448	0.71619	24	3	3	23	30	23
21	snacks, crackers & chips	0.77893	0.91071	0.92814	37	20	19	32	24	24
22	sugar	1.00000	0.84604	0.88347	24	15	13	25	2	25
23	cocoa products	1.00000	0.75076	0.81002	24	6	7	26	2	26
24	chocolate products & sugar confectionery	1.01759	0.93995	0.95312	20	23	21	27	30	27
25	macaroni, noodles & similar products	1.01852	0.77976	0.84856	19	8	11	29	29	29
26	coffee	1.01325	0.91454	0.96570	21	21	22	30	29	30
27	tea	1.42011	0.97683	0.98610	6	27	26	31	31	31
28	sauces including flavoring extracts	1.01977	0.87086	0.89246	18	17	15	32	32	32
29	spices & curry powder	1.12834	0.85475	0.90256	14	16	17	33	33	33
30	other food products	0.93949	0.81265	0.84606	36	12	9	32	30	30
31	spirits; ethyl alcohol production from fermented materials	1.65179	0.97793	0.97793	4	28	24	31	31	31
32	wines, malt liquors & malt	1.00000	1.04728	1.07311	24	34	34	32	32	30
33	soft drinks	0.99524	0.71428	0.79593	35	5	5	25	4	37
34	mineral water	1.06119	0.89615	0.93962	16	18	20	34	34	34

Figure 2: Order-m efficiency score in 2009 (Source: Author calculation)

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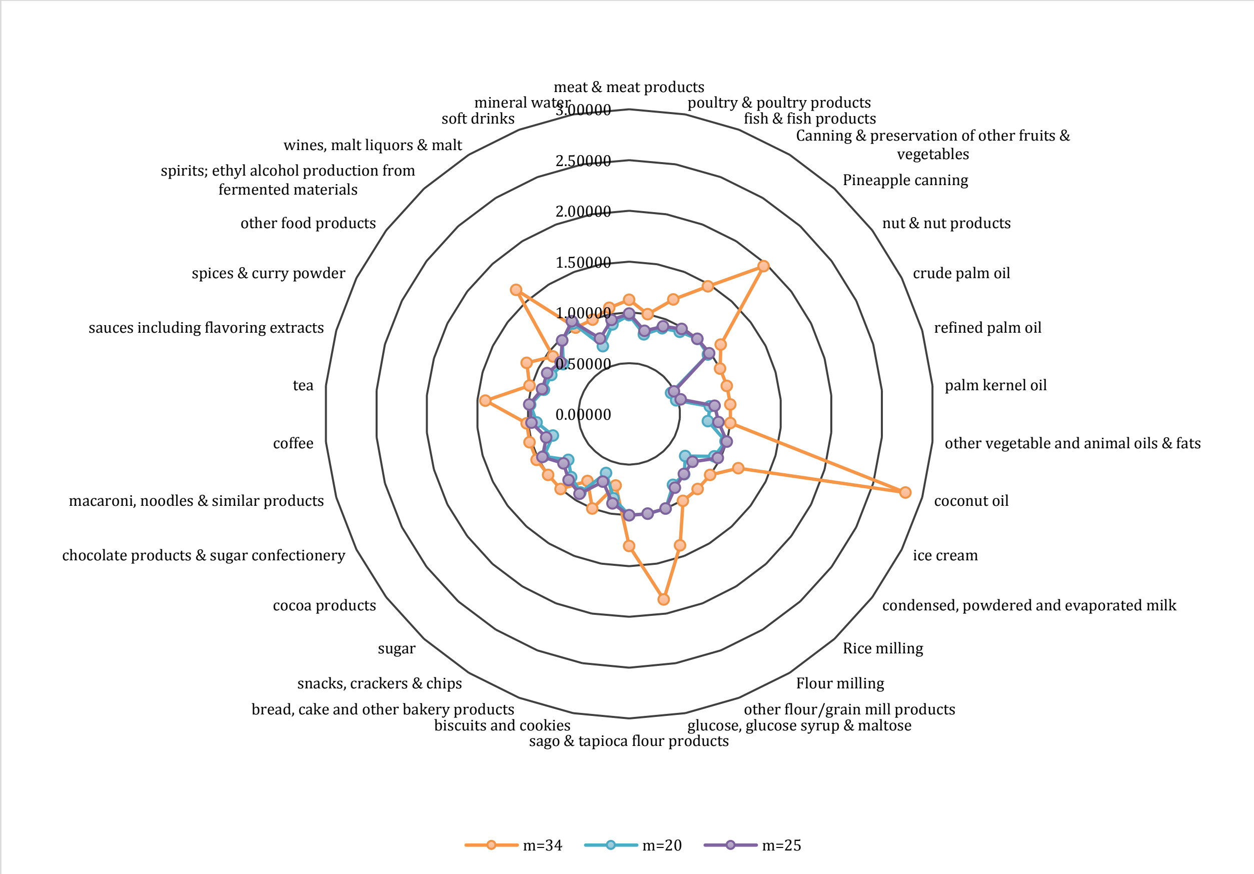


Figure 3: Order-m efficiency score in 2010 (Source: Author calculation)

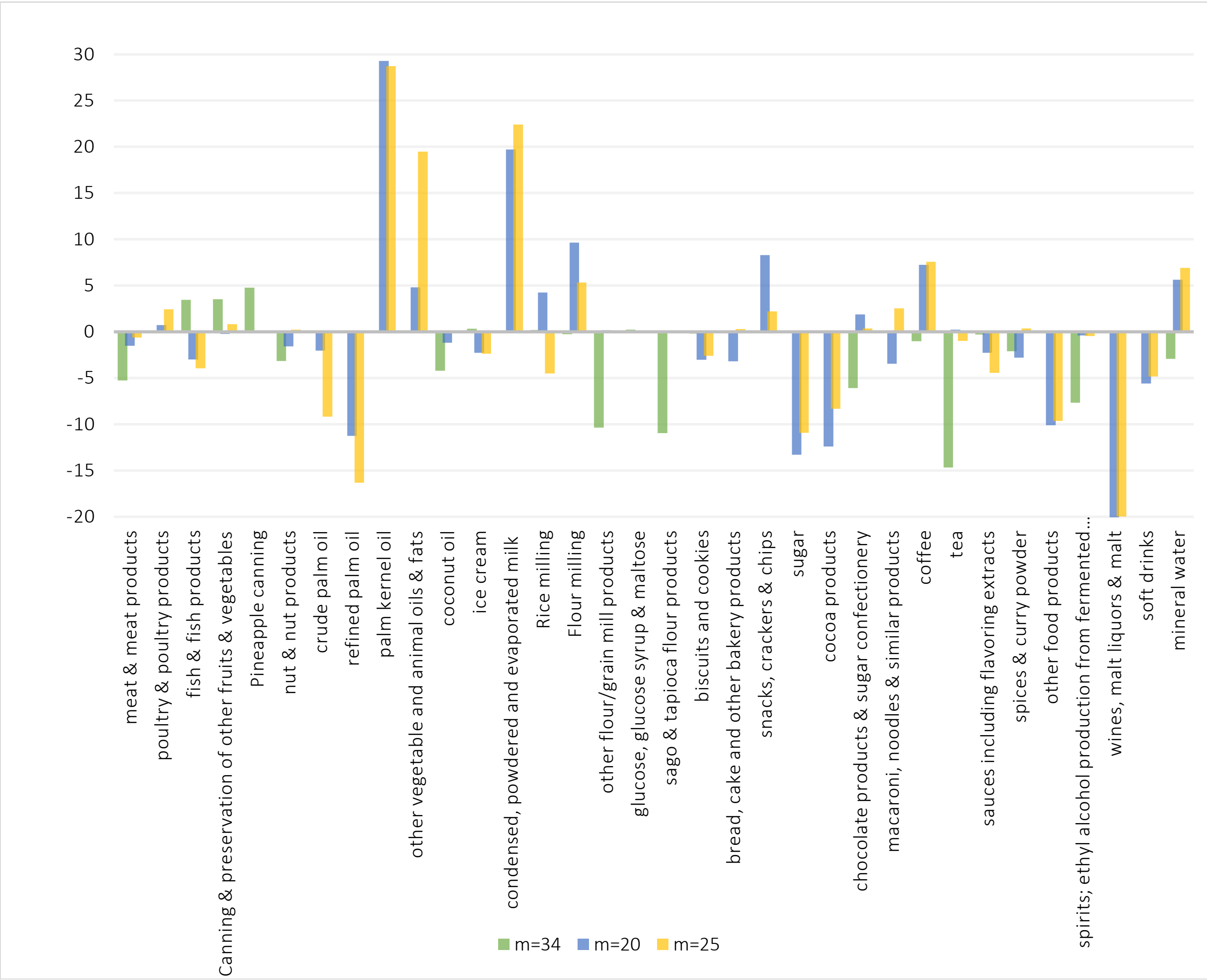


Figure 4: Percentage increase or decrease in efficiency score from 2009 to 2010 (Source: Author calculation)

6. CONCLUSION AND POLICY SUGGESTIONS

The key contributions of this study to the existing literature are as follows:

1. There is an introduction to MPI analysis to the existing literature for analyzing total factor productivity and technological change efficiency of the food processing industry.

   Findings: MPI analysis enabled us to examine the performance of technological and technical efficiency separately and the contribution of organic composition as well as the contribution of technology to the total factor productivity of the sectors more comprehensively;

2. A search of the literature indicates this is the first time in the analysis of the food processing industry that a study has used both partial frontier (m = 20 and m = 25) as well as full frontier (m = 34) order-m analysis. The m stands for number of industries in this research.

   Findings: This has enabled us to examine which food processing industry has performed most efficiently, providing insights for other food processors. This approach has also helped us to review the variation in the efficiency score of the industries over the one-year period under consideration. Moreover, the study also found the order m method to be efficient and consistence unlike other non-parametric methods such as DEA, FDH etc.

3. The study also presented technical intensiveness and technological intensiveness as factors determining comparative and absolute advantage for each industry in addition to the factors, such as lower cost of inputs and higher value of output, which were used in previous studies.

   Findings: The results strongly indicate that for the majority of industries, better performance is the result of an improvement in technological efficiency rather than organic composition. Almost all industries show negativity in the improvement of organic composition in their production processes, with the exception of Manufacturer of Palm Kernel Oil for which organic composition was a significant contributor in the overall increase in total factor productivity efficiency.

This is an important finding, because since technological efficiency increases are likely the result of developments external to the industry and the firms that comprise it, it suggests that there is still scope for improvement in the internal management practices and resource allocation decision of these high performing industries. In other words, the best-practice production frontier is moving upward thereby increasing total factor productivity, but the extent to which firms are moving towards the frontier by improving internal practices is less positive. Indeed, it could be speculated that the trend of continually increasing technological efficiency in the food processing industry reduces the incentives for firms to strive for technical efficiency within their organizations.

While this is largely a matter for the firms themselves, it has policy implications simply in the recognition that firms are not moving towards their production frontiers. More work would need to be done to ascertain why but if, for example, this is because of barriers to the improvement in organic composition, policies could be considered to address this. This methodology would be equally valuable in other industries, given the availability of appropriate data.The main limitation of this study is the lack of availability of the data. The data used here is only for two years, 2009 and 2010, therefore the results show some inconsistency in the outcome. The dataset used in this study has been collected in association with University Malaysia Sabah (UMS), University Putra Malaysia (UPM) and Malaysian government. Data for the year 2012 was available, but unusable for this study because it lacked the balanced panel feature for analysis. Also, a deeper understanding of how intensive an industry is to organic composition or technology wasn't possible due to lack of appropriate data. Additionally, this study has used only a non-parametric approach to the analysis. Hence, the suggestion to future researchers would be to use more years of data in their analysis, as well as to use additional data for analyzing the intensiveness to organic composition or technology of each industry. It would also be possible to use parametric approaches such as simple OLS or GLS regression analysis besides the non-parametric approaches used in this study.

APPENDIX

Note 1: Organic Composition

The organic composition of a firm or industry is the ratio of constant capital to variable capital which is required to produce one unit of output of that firm or industry. This can be referred to as an indicator of technical efficiency of a firm explaining how the factors of production work together to produce a desired amount of output. A higher value of organic composition means that the production process is capital-intensive, and the lower value means that the production process is labor-intensive. Any increase in organic composition will indicate improvement in the technical efficiency of the firm/industry.

Note 2: Non-Parametric Statistics

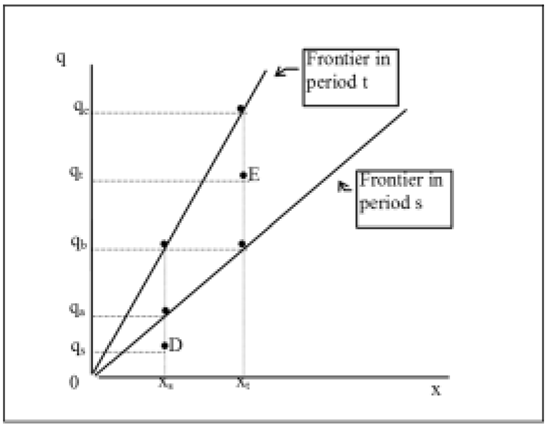
Nonparametric statistics refer to a statistical method used to analyze ordinal or nominal data with small sample sizes, wherein the data does not require any assumptions regarding the distribution of the population. Non-parametric methods are also referred as distribution free method. The contemporary nonparametric methods are data envelopment analysis (DEA), free disposal hull (FDH), order-α and order-m frontier analysis, etc.

Note 3: Pseudo Reference

The order-m analysis suggests some reference DMUs which should be followed by the respondent DMU in order to achieve higher degree of efficiency. This reference DMU is called pseudo reference.

Note 4: Malmquist Productivity Index (MPI)

MPI measures the change in efficiency of a DMU between different time periods. The Malmquist productivity index does not satisfy the transitivity property and also does not adequately account for scale change. The input and output oriented indices coincide if the technology exhibits constant return to scale. MPI can be decomposed into efficiency change and technical change.



Note 5: Data Envelopment Analysis (DEA)

It is a nonparametric mathematical programming approach to frontier estimation. DEA method is popularly used to calculate MPI of TFP change.

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