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Application of the Malmquist Productivity Index on Measurement of Productivity Trend of Durian Production in Thailand

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ABSTRACT: *The purpose of this paper is to measure the productivity changes and to estimate the durian productivity trend in different province of Thailand using the Malmquist Productivity Index model during the period 2012-2016. Malmquist index of Thai durian production had an upward trend from 2012 to 2016. The findings indicate that the productivity index has increased, which means that the country has improved in productivity for durian production. Moreover, the study found that the Chanthaburi province has the highest productivity growth among the 22 province followed by Suratthani province, Narathiwat province, Yala province, Phatthalung province, Rayong province, Satun province, Phuket province, Chumphon province, Phangnga province, Songkhla province, Ranong province, Nakornsrithammarat province, Pattani province, Krabi province, Nakhonphanom province, Trang province, Trat province, Uttaradit province, Nakhonnayok province, Nonthaburi province and finally the Prachinburi province. Therefore, this paper can provide important information farmers, agricultural planners and government agencies to help increase the productivity of durian production in Thailand.*

KEYWORDS: *Durian production, Malmquist Productivity Index, Productivity change, Productivity trend, Thailand*

I. INTRODUCTION

Durian is a popular fruit in Southeast Asia and is also known as the King of Fruits. Thailand is the largest producer of world durian production. In 2016, the total durian production was around 656,777 tons (OAE, 2016). Moreover, Thailand is the world's largest exporter of durian and the major export markets are Taiwan, Hong Kong, China, Malaysia and United States. The main of durian growing areas are eastern region and southern region of Thailand (Subhadrabandhu, 1990). According to National Statistical Office, Thailand has planted area more than 0.1 million hectares and the total of harvested area has increased continuously in the recent years. In addition, durian production is associated with 0.3 million families of farmers, with more than 1 million people across the whole country, including employers, workers, and government officials (OAE, 2016). According to economic theory, the basic factors of production (land, labor and capital) have been considered as a parameter to evaluate the trend of productivity change (Van Passel, Van Huylenbroeck, Lauwers, & Mathijs, 2009). Coelli (1996) and Pingali and Xuan (1992) point out that input variables and output variables are important for analyzing trends in productivity levels. Krasachat (2003) measured the efficiency of agricultural production in Thailand and had one output variable (quantity of farm produce) and had six input variables (land, capital, labor, fertilizer and other inputs). Previous studies have focused on the efficacy of durian farms in Thailand (Krasachat, 2004) but few studies have examined on the productivity trend in durian production in different areas of Thailand. Therefore, this study aims to measure the productivity changes and to estimate the durian productivity trend in different province of Thailand from 2012 to 2016 by using Malmquist Productivity Index model. As mentioned, previous researchers have shown that the concept of Malmquist Productivity Index approach have been developed for evaluating total factor productivity change, efficiency change, and technical change (Asmild, Paradi, Aggarwall, & Schaffnit, 2004). According to Malmquist (1953), Malmquist

Productivity Index model was applied to measure the productivity of different firms or units operating under different technologies. Son Nghiem and Coelli (2002) studied the trends of agricultural production in Vietnam using Malmquist Productivity Index technique and the results found that there was a strong average total factor productivity change growth and the productivity growth differs between regions. Odeck (2009) found that Malmquist Productivity Index was the optimal technique for evaluating the performance of grain farm in Norway from 1987 to 1997. Nomikos and Pouliasis (2011) attempted to measure efficiency of agricultural industry in India and the result reported that there has been a declining growth rate of capacity utilization in Indian agricultural industry during the post reforms period accompanied by declining output growth as well as capacity growth. Therefore, the literature review of Malmquist Productivity Index model demonstrates that this outstanding technique is an appropriate and useful method for measuring the productivity change over time.

II. METHODOLOGY

2.1 Malmquist Productivity Index (MPI)

The Malmquist Index was suggested by Malmquist (1953). Malmquist Productivity Index model only requires some information on quantities of inputs used and outputs produced. Productivity is the measurement of the relationship between input variables and output variable that have gone into producing those outputs. Malmquist Productivity Index is a very useful method for measuring the productivity changes that has the advantage of evaluating multiple input and output variables over time (Arabi, Munisamy, Emrouznejad, & Shadman, 2014). Fare, Grosskopf, Norris, and Zhang (1994) indicated that a distance function in input-oriented Malmquist Productivity Index approach can effectively measure the productivity change of a given DMU between time *t* and *t*+1 as shown in Equation (1):

$$M_i\ (y^{t+1}, x^{t+1}, y^t, x^t) = \left[\left(\frac{D_i^t(x^{t+1},y^{t+1})}{D_i^{t+1}(x^{t+1},y^{t+1})}\right)\left(\frac{D_i^t(x^t,y^t)}{D_i^{t+1}(x^t,y^t)}\right)\right]^{\frac{1}{2}} \quad (1)$$

Where M_i shows the input-oriented Malmquist Productivity Index approach and *D* means the distance function. According to Fare et al. (1994), Malmquist Productivity Index can be decomposed into two components. The first component is a measure of technical change in a production technology. The second component is a measure of efficiency change in a gap between maximum feasible production and observed production function. Thus, Malmquist Productivity Index approach can be written as Equation (2) and Equation (3).

$$M_o\ (y^{t+1}, x^{t+1}, y^t, x^t) = \left[\left(\frac{D_o^t(x^{t+1},y^{t+1})}{D_o^{t+1}(x^{t+1},y^{t+1})}\right)\left(\frac{D_o^t(x^t,y^t)}{D_o^{t+1}(x^t,y^t)}\right)\right]^{\frac{1}{2}} \text{ x } \frac{D_o^{t+1}(x^{t+1},y^{t+1})}{D_o^t(x^t,y^t)} \quad (2)$$

$$= \text{Technical Change (TC) x Efficiency Change (EC)} \quad (3)$$

The M_o performs a value greater than, equal to one, or less than one if a given DMU has experienced productivity growth, stagnation, or productivity decline, between periods *t* and *t*+1, respectively. If TC > 1 represents a good technology improvement, TC = 1 means unchanged technology and TC < 1 indicates deteriorating technology. In addition, EC > 1 represents the increase of efficiency of durian production from period *t* to *t* + 1; EC = 1 shows the unchanged efficiency and EC < 1 indicates the decrease of efficiency of durian production from the period *t* to *t* + 1. Therefore, M >1 shows the productivity growth; M = 1 represents the unchanged growth rate for productivity and M < 1 means the productivity decline.

2.2 Data and Variables

We analyzed durian production in Thailand from 2012 to 2016. The study examined 22 provinces across four regions in Thailand, namely Chanthaburi, Chumphon, Krabi, Nakhonnayok, Nakhonphanom, Nakornsrithammarat, Narathiwat, Nonthaburi, Pattani, Phangnga, Phatthalung, Phuket, Prachinburi, Ranong, Rayong, Satun, Songkhla, Suratthani, Trang, Trat, Uttaradit and Yala. Therefore, we used the secondary data collected from surveys through various Thai governmental agencies: Ministry of Labor, Ministry of Agriculture and Cooperatives and Office of Agricultural Economics. We analyzed a total of six inputs, namely X1 (planted area), X2 (harvested area), X3 (human labor), X4 (fertilizer), X5 (pesticide) and X6 (machinery), and one

output, namely Y (durian quantity). Table 1 shows the data descriptions. Data analyses were conducted using data envelopment analysis program (DEAP 2.1) and statistical package for social sciences (SPSS 23.0). The descriptive statistics for each variable used in this study are shown in Table 2. The average planted area was 107,762 hectare, harvested area was 94,854 hectare, 1,429 hour/hectare of human labor in durian production sector, fertilizer used 18,358 tons, pesticide was 2,130 tons and also machinery was 32 hour/hectare. Moreover, the average durian quantity was 752,912 tons.

Table 1: Data descriptions of variables items and resource

Variables	Unit	Definition	Source
Inputs			
Planted area (X1)	hectare (ha)	Agricultural land that is used for durian growing.	Mohammadi et al. (2015)and Krasachat (2014)
Harvested area (X2)	hectare (ha)	Total area for durian production.	Tung (2014) and Krasachat (2012)
Human labor (X3)	hour per ha (hr/ha)	The workers who are 15-60 years old and engaged in durian production.	Krasachat (2014) and Rahman, Wiboonpongse, Sriboonchitta, and Chaovanapoonphol (2009)
Fertilizer (X4)	tons	Total number of the chemical fertilizers used in durian-farming production.	Mailena, Shamsudin, Radam, and Latief (2014), Nassiri and Singh (2009) and Dhungana, Nuthall, and Nartea (2004)
Pesticide (X5)	tons	Total number of substances that are intently used for destroying, mitigating and preventing any pest. Pesticides included insecticides, herbicides, fungicide and bactericides.	Mailena et al. (2014) and Tung (2014)
Machinery (X6)	hour per hectare (hr/ha)	The total power of farm machinery.	Nassiri and Singh (2009) and Rahman and Rahman (2009)
Output			
Durian quantity (Y)	tons	Total durian quantity of all the production.	Krasachat (2014), Krasachat (2012)

Source: Author's composition.

Table 2: Descriptive statistics of the inputs and output in Thailand

Variables	Unit	Average	Standard deviation	Maximum	Minimum
Inputs					
Planted area (X1)	hectare (ha)	107,762	98,802	208,389	5,290
Harvested area (X2)	hectare (ha)	94,854	91,471	130,843	3,366
Human labor (X3)	hour per ha (hr/ha)	1,429	1,093	3,492	340
Fertilizer (X4)	tons	18,358	14,658	43,930	2,540
Pesticide (X5)	tons	2,130	1,185	4,320	643
Machinery (X6)	hour per hectare (hr/ha)	32	13	55	12
Output					
Durian quantity (Y)	tons	752,912	602,450	653,921	58

Source: Author's calculations.

III. RESULTS AND DISCUSSION

The study measured the change in the productivity trend of durian production in Thailand from 2012 to 2016 by using the MPI for empirical estimation. According to MPI theory, total factor productivity change (TFP) can be decomposed into two components, namely, technical change (TC) and efficiency change (EC), it can be seen that both components have a direct impact on productivity change. Table 3 shows that the results of the Malmquist productivity index of Thai durian production from 2012-2016. The results found that the average of total factor productivity change was 1.037, average of technical change was 1.061 and average efficiency change was 0.978, therefore, we concluded that the production of durian in Thailand has improved in the studied period from 2012 to 2016, as suggested by the Malmquist total factor productivity change of durian production and the value of total factor productivity change.

Chanthaburi province had growth rates of efficiency increased in crop years 2012-2013, 2014-2015 and 2015-2016 and had growth rates of efficiency decreased in only year 2013-2014, which can be seen that the overall production trend of this province is increasing.

Chumphon province has shown efficiency improvements and technical progress in crop years 2013-2014 and 2014-2015 and has shown inefficiency and technical recession in crop years 2012-2013 and 2015-2016; thus, the productivity trend of Chumphon province is increasing.

Krabi province had a positive productivity trend in only crop year 2012-2013, moreover, 2013-2014, 2014-2015 and 2015-2016 had a negative productivity trend; therefore, the productivity trend of this province is decreasing.

Nakhonnayok province had negative growth rate from crop years 2012-2013 to 2015-2016 and an overview of this province is likely to decline in durian production.

Nakhonphanom province had positive growth rates in crop years 2012-2013 and 2014-2015 and had negative growth rate from crop years 2013-2014 and 2015-2016; thus, the productivity trend of this province is decreasing.

Nakornsrithammarat province had growth rates of efficiency increased in only year 2014-2015 and had growth rates of efficiency decreased in crop years 2012-2013, 2013-2014 and 2015-2016; the overall production trend of this province is decreasing.

Narathiwat province had growth rates of efficiency increased in crop years 2012-2013, 2014-2015 and 2015-2016 and in crop year 2013-2014 had growth rates of efficiency decreased; thus, the productivity trend of Narathiwat province is increasing.

Nonthaburi province had a positive productivity trend in crop year 2012-2013 and had a negative productivity trend in crop years 2013-2014, 2014-2015 and 2015-2016l; all of durian production in this province is decreasing.

Pattani province has shown efficiency improvements and technical progress in crop year 2012-2013 and has shown inefficiency and technical recession in crop years 2013-2014, 2014-2015 and 2015-2016; the overview of productivity trend in Pattani province is decreasing.

Phangnga province had growth rates of efficiency increased in crop year 2014-2015 and had growth rates of efficiency decreased in crop years 2012-2013, 2013-2014 and 2015-2016; thus, the productivity trend of this region is increasing.

Phatthalung province has shown efficiency improvements and technical progress from crop years 2012-2013 to 2015-2016; the overview of durian production in this province is increasing.

Phuket province had negative growth rate in crop years 2012-2013 and 2015-2016 and had positive growth rates in crop years 2013-2014 and 2014-2015; therefore, the productivity trend of this province is increasing.

Prachinburi province had growth rates of efficiency increased in only year 2012-2013 and 2013-2014, 2014-2015 and 2015-2016 had growth rates of efficiency decreased; which can be seen that the overall production trend of Prachinburi province is decreasing.

Ranong province had a positive productivity trend in crop years 2012-2013 and 2014-2015 and had a negative productivity trend in crop years 2013-2014 and 2015-2016; all of durian production in this province is increasing.

Rayong province had growth rates of efficiency increased in crop year 2012-2013 and had growth rates of efficiency decreased in crop years 2013-2014, 2014-2015 and 2015-2016; thus, the productivity trend of this region is increasing.

Satun province had positive growth rates in crop year 2013-2014 and had negative growth rate in crop years 2012-2013, 2014-2015 and 2015-2016, and the overall of this province is likely to increase for durian production.

Songkhla province had a negative productivity trend in crop years 2012-2013 and 2014-2015 and had a positive productivity trend in crop years 2013-2014 and 2015-2016; therefore, the productivity trend of Songkhla province is increasing.

Suratthani province has shown efficiency improvements and technical progress in crop years 2012-2013, 2013-2014 and 2015-2016 and in crop year 2014-2015 has shown inefficiency and technical recession; the overall production trend of this province is increasing.

Trang province had negative growth rate in crop years 2012-2013, 2013-2014 and 2014-2015 and in crop year 2015-2016 had positive growth rates; thus, the productivity trend of Trang province is decreasing.

Trat province had growth rates of efficiency decreased in crop years 2012-2013, 2013-2014, 2014-2015 and 2015-2016, which can be seen that the overall production trend of Trat province is decreasing.

Uttaradit province had a negative productivity trend in crop years 2012-2013, 2014-2015 and 2015-2016 and had a positive productivity trend in crop year 2013-2014; thus, the productivity trend of Uttaradit province is decreasing.

Yala province had negative growth rate in crop year 2012-2013 and had positive growth rates in crop years 2013-2014, 2014-2015 and 2015-2016; the overall production trend of Yala province is increasing.

It overall, the Chanthaburi province has the highest productivity growth among the 22 province followed by Suratthani province, Narathiwat province, Yala province, Phatthalung province, Rayong province, Satun province, Phuket province, Chumphon province, Phangnga province, Songkhla province, Ranong province, Nakornsrithammarat province, Pattani province, Krabi province, Nakhonphanom province, Trang province, Trat province, Uttaradit province, Nakhonnayok province, Nonthaburi province and finally the Prachinburi province. Therefore, we summarized that durian production in Thailand has improved efficiency, technical progress and productivity growth during 2012-2016.

Table 3: Malmquist productivity index summary of annual means

Provinces	Crop Years	Technical Change (TC)	Efficiency Change (EC)	Total Factor Productivity Change (TFP)	Estimates of the productivity trend
Chanthaburi	2012-2013	1.580	0.983	1.553	increasing
	2013-2014	0.982	0.997	0.979	decreasing
	2014-2015	1.178	1.083	1.275	increasing
	2015-2016	1.286	0.984	1.265	increasing
	Average	1.257	1.012	1.271	increasing
Chumphon	2012-2013	0.975	0.884	0.862	decreasing
	2013-2014	1.083	1.190	1.289	increasing
	2014-2015	1.028	1.018	1.046	increasing
	2015-2016	0.967	1.019	0.985	decreasing
	Average	1.013	1.028	1.041	increasing
Krabi	2012-2013	1.128	1.057	1.192	increasing
	2013-2014	0.984	0.999	0.983	decreasing
	2014-2015	0.977	0.823	0.804	decreasing
	2015-2016	1.041	0.927	0.965	decreasing
	Average	1.033	0.952	0.982	decreasing

Source: Author's calculations.

Table 3: *Cont.*

Provinces	Crop Years	Technical Change (TC)	Efficiency Change (EC)	Total Factor Productivity Change (TFP)	Estimates of the productivity trend
Nakhonnayok	2012-2013	0.837	0.977	0.818	decreasing
	2013-2014	0.788	1.193	0.940	decreasing
	2014-2015	0.889	1.087	0.966	decreasing
	2015-2016	1.000	0.982	0.982	decreasing
	Average	0.879	1.060	0.931	decreasing
Nakhonphanom	2012-2013	1.153	1.029	1.186	increasing
	2013-2014	1.000	0.912	0.912	decreasing
	2014-2015	1.021	1.013	1.034	increasing
	2015-2016	0.977	0.831	0.812	decreasing
	Average	1.038	0.946	0.982	decreasing
Nakornsrithammarat	2012-2013	1.000	0.789	0.789	decreasing
	2013-2014	0.981	0.999	0.980	decreasing
	2014-2015	1.192	1.037	1.236	increasing
	2015-2016	0.982	0.998	0.980	decreasing
	Average	1.039	0.956	0.993	decreasing
Narathiwat	2012-2013	1.084	1.382	1.498	increasing
	2013-2014	1.000	0.892	0.892	decreasing
	2014-2015	1.172	0.982	1.151	increasing
	2015-2016	1.056	1.129	1.192	increasing
	Average	1.078	1.096	1.182	increasing
Nonthaburi	2012-2013	1.048	0.980	1.027	increasing
	2013-2014	1.012	0.930	0.941	decreasing
	2014-2015	0.879	1.032	0.907	decreasing
	2015-2016	1.000	0.783	0.783	decreasing
	Average	0.985	0.931	0.917	decreasing
Pattani	2012-2013	1.087	1.299	1.412	increasing
	2013-2014	1.000	0.892	0.892	decreasing
	2014-2015	0.988	0.832	0.822	decreasing
	2015-2016	0.900	0.968	0.871	decreasing
	Average	0.994	0.998	0.992	decreasing
Phangnga	2012-2013	0.914	1.054	0.963	decreasing
	2013-2014	0.964	1.012	0.975	decreasing
	2014-2015	1.179	1.063	1.253	increasing
	2015-2016	0.839	1.120	0.940	decreasing
	Average	0.974	1.062	1.035	increasing
Phatthalung	2012-2013	1.083	0.974	1.054	increasing
	2013-2014	0.938	1.085	1.017	increasing
	2014-2015	1.195	0.869	1.038	increasing
	2015-2016	1.280	1.094	1.400	increasing
	Average	1.124	1.006	1.130	increasing
Phuket	2012-2013	1.018	0.943	0.960	decreasing
	2013-2014	1.290	0.965	1.245	increasing
	2014-2015	1.175	1.022	1.200	increasing
	2015-2016	1.000	0.833	0.833	decreasing
	Average	1.121	0.941	1.054	increasing

Source: Author's calculations.

Table 3: *Cont.*

Provinces	Crop Years	Technical Change (TC)	Efficiency Change (EC)	Total Factor Productivity Change (TFP)	Estimates of the productivity trend
Prachinburi	2012-2013	1.007	0.994	1.000	increasing
	2013-2014	0.984	0.847	0.833	decreasing
	2014-2015	1.000	0.874	0.874	decreasing
	2015-2016	1.045	0.805	0.841	decreasing
	Average	1.009	0.880	0.888	decreasing
Ranong	2012-2013	1.340	0.958	1.284	increasing
	2013-2014	1.082	0.780	0.843	decreasing
	2014-2015	1.055	0.983	1.037	increasing
	2015-2016	1.000	0.922	0.922	decreasing
	Average	1.119	0.911	1.019	increasing
Rayong	2012-2013	1.543	0.938	1.447	increasing
	2013-2014	0.872	1.094	0.954	decreasing
	2014-2015	1.123	0.853	0.958	decreasing
	2015-2016	1.000	0.878	0.878	decreasing
	Average	1.135	0.941	1.067	increasing
Satun	2012-2013	1.028	0.923	0.949	decreasing
	2013-2014	1.073	1.231	1.321	increasing
	2014-2015	1.028	0.962	0.989	decreasing
	2015-2016	0.927	1.076	0.997	decreasing
	Average	1.014	1.048	1.063	increasing
Songkhla	2012-2013	1.000	0.931	0.931	decreasing
	2013-2014	1.233	0.890	1.097	increasing
	2014-2015	0.980	0.843	0.826	decreasing
	2015-2016	1.092	1.156	1.262	increasing
	Average	1.076	0.955	1.028	increasing
Suratthani	2012-2013	1.320	0.975	1.287	increasing
	2013-2014	1.793	0.934	1.675	increasing
	2014-2015	1.072	0.877	0.940	decreasing
	2015-2016	0.975	1.032	1.006	increasing
	Average	1.290	0.955	1.231	increasing
Trang	2012-2013	1.013	0.920	0.932	decreasing
	2013-2014	0.862	1.008	0.869	decreasing
	2014-2015	1.000	0.856	0.856	decreasing
	2015-2016	1.158	1.055	1.221	increasing
	Average	1.008	0.960	0.968	decreasing
Trat	2012-2013	0.914	1.082	0.989	decreasing
	2013-2014	1.194	0.833	0.994	decreasing
	2014-2015	0.854	1.134	0.968	decreasing
	2015-2016	1.029	0.805	0.828	decreasing
	Average	0.998	0.964	0.961	decreasing
Uttaradit	2012-2013	1.000	0.932	0.932	decreasing
	2013-2014	1.184	0.911	1.079	increasing
	2014-2015	0.915	0.865	0.791	decreasing
	2015-2016	1.066	0.912	0.972	decreasing
	Average	1.041	0.905	0.942	decreasing

Source: Author's calculations.

Table 3: *Cont.*

Provinces	Crop Years	Technical Change (TC)	Efficiency Change (EC)	Total Factor Productivity Change (TFP)	Estimates of the productivity trend
Yala	2012-2013	1.045	0.890	0.930	decreasing
	2013-2014	0.996	1.135	1.130	increasing
	2014-2015	1.280	1.078	1.380	increasing
	2015-2016	1.134	0.974	1.104	increasing
	Average	1.114	1.019	1.135	increasing
Average		1.061	0.978	1.037	increasing

Source: Author's calculations.

IV. CONCLUSIONS

This study used the Malmquist Productivity Index to measure the productivity changes in durian production efficiency and to estimate the durian productivity trend from 2012 to 2016. In addition, the research areas consisted of 22 provinces in Thailand. Malmquist index of durian production showed an upward trend due to the technical change and the efficiency change has increased. Thus, the results showed that the productivity index has increased, which means that the country has improved in productivity for durian production. Demand for durian is likely to increase. Chanthaburi province, Chumphon province, Narathiwat province, Phangnga province, Phatthalung province, Phuket province, Ranong province, Rayong province, Satun province, Songkhla province, Suratthani province and Yala province had a progression in total factor productivity change that were mainly caused by the upward trends in the technical change and efficiency change for Thai durian production during the period of this study. Moreover, Krabi province, Nakhonnayok province, Nakhonphanom province, Nakornsrithammarat province, Nonthaburi province, Pattani province, Prachinburi province, Trang province, Trat province and Uttaradit province found a downward trend in the total factor productivity change. Durian production in Thailand has been varying among 22 provinces because each province has different trend of durian production. Furthermore, this study can provide important information to farmers, planners and government agencies to define strategies that are useful and helpful to increase the efficiency in each province for Thai durian production.

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