Total Factor Productivity Growth of Indonesian Crude Palm Oil Production

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ABSTRACT

Indonesia is currently the world's largest producer of palm oil. With the advancement of technology and other advantageous resources such as human capital, the annual palm oil yield increased, but on the other hand, cost also increased. To monitor the actual productivity growth of palm oil production which is not explained by the amount of labor and capital used in production process, total factor productivity (TFP) calculation is needed. This research analyses TFP growth of palm oil production in Indonesia from high productivity plantations.

Keywords: total factor productivity, crude palm oil, Indonesia
JEL classifications: D24, O47, O13, Q19

I. INTRODUCTION

Palm oil is perhaps one of the most versatile materials, used in a wide range of products from food products, biodiesel, to cosmetics all over the world. Grown mostly in tropical areas of the world, it has become Indonesia's biggest source of foreign exchange income. Based on data from Statistics Indonesia (BPS), Indonesia's main foreign exchange earner is still palm oil, amounted to US$ 22.97 billion in 2018, followed by coal at US$ 21.07 billion, and oil and gas at around US$ 13.1 billion.

Based on Indonesia's Ministry of Agriculture's data, the total area of oil palm plantations in Indonesia increased from about 300,000 hectares in 1980 to about 11.6 million hectares in 2016. Crude palm oil production also increased from 700,000 tons in 1980 to 33.5 million tons in 2016.

Currently, the area of oil palm plantations spread in 25 provinces, namely all provinces in Sumatra and Kalimantan, West Java, Banten, Central Sulawesi, South Sulawesi, Southeast Sulawesi, West Sulawesi, Gorontalo, Maluku, Papua and West Papua. Of the 25 provinces, Riau Province is the province with the largest oil palm plantation area in Indonesia, which has 2 million hectares of palm plantations in 2016 or 18 percent of the total area of oil palm plantations in Indonesia. In 2017 the area of oil palm plantations in Riau Province was estimated at 2.26 million hectares.

Figure 1 below shows the comparison of oil palm plantation area growth and total CPO yield growth over the years. Even though the total area didn't gain dramatically increase, that is not the case with the total CPO yield. We can conclude that the overall productivity per unit area increased dramatically.

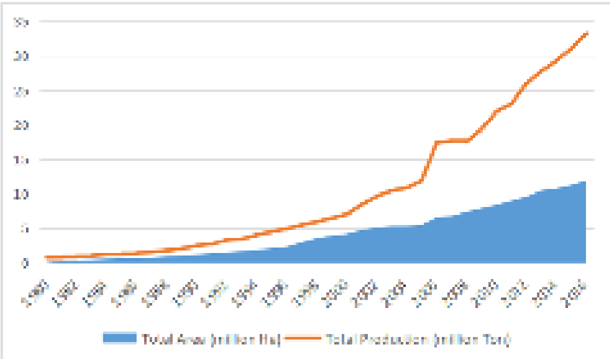

Figure. 1. Comparison of growths of total oil palm plantation area and total yield (author's analysis from Indonesian Oil Palm Statistics 2017, BPS-Statistics Indonesia).

After the Green Revolution, in the late 1990s and early 2000s, Indonesia's agricultural productivity growth shifted away from food crops such as rice to perennial export crops such as oil palm (Rada, Buccola and Fuglie, 2011). This explains the significant increase in oil palm's productivity per unit area from the year 2000 onwards as shown in Figure 1.

There are two types of plantations according to the form and scale of their business referring to the 2012 Agricultural Statistics Concept and Standard Definition published by BPS, which are *large plantations* and *smallholder plantations*. Large plantations are plantations that are organized or managed commercially by companies that are legal entities. Large plantations consist of State Plantations (PBN) and National/Foreign Private Plantation (PBS), while Smallholders Plantations are owned by personals and not incorporated.

The comparison of CPO yields by their farming category is shown in Figure 2 below. Based on this figure, state plantations and private plantations showed some interesting fluctuations over the years, while smallholder plantations' yield grew quite steadily in comparison. However, state and private plantations generally still have higher CPO yield per hectare in the past 18 years compared to smallholder plantations. CPO production per hectare even once reached a whopping 4.068 tons per hectare in 1994.

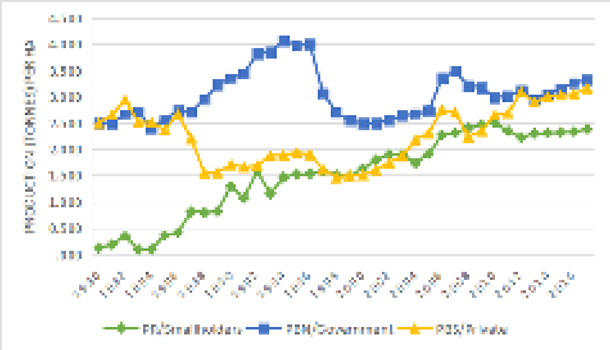

Figure 2. CPO Production Yield per Unit Area by Farming Category (author's analysis from Indonesian Oil Palm Statistics 2017, BPS-Statistics Indonesia).

From these findings, it can be concluded that there is still room for growth for bigger production yield in the future, if the potential of the already existing plantations, especially smallholder's plantations, can be maximized. In order to understand better the biggest contributing factors to private estate's total factor productivity of palm oil and how much those contributing factors affect private estate's CPO yield over the years, in this paper TFP calculation is used.

II. LITERATURE REVIEW

Total Factor Productivity (TFP) is the portion of output not explained by the amount of inputs used in production. As such, its level is determined by how efficiently and intensely the inputs are utilized in production. Total factor productivity is a measure of economic efficiency and accounts for part of the differences in cross-country per-capita income. The rate of TFP growth is calculated by subtracting growth rates of labor and capital inputs from the growth rate of output (Comin, 2006).

TFP plays a critical role in economic fluctuations, economic growth and cross-country per capita income differences (Comin, 2006). Rate of economic growth depends on the growth rate of the resources used. Investopedia explained that economic growth is an increase in the production of economic goods and services, compared from one period of time to another. It can be measured in nominal or real (adjusted for inflation) terms. Increases in capital goods, labor force, technology, and human capital can all contribute to economic growth. Economic growth is commonly measured in terms of the increase in aggregated market value of additional goods and services produced, using estimates such as GDP.

Therefore, mathematically economic growth is expressed by the growth rate of supply resources such as labor and capital, plus the rate of increase in TFP. So the amount by which output increased due to the increase in labor will depend on the share of contribution of said labor. Likewise, the amount by which output increased due to the increase in capital will depend on the share of contribution of said capital.

The process of calculating derives TFP as the residual which accounts for effects on total output not caused by inputs such as labor and capital. TFP growth is usually measured by the Solow residual.

The equation below in Cobb–Douglas form represents total output (Y) as a function of total-factor productivity (A), capital input (K), labor input (L), and the two inputs' respective shares of output where α and β are the shares of contribution for K and L respectively (Cobb, C. W. et al., 1928). An increase in either A, K or L will lead to an increase in output.

$$Y = A \times K^{\alpha} \times L^{\beta} \tag{1}$$

The function describes that the greater the value of A, the more advanced technology is and the bigger output can be yielded.

In productivity measurement, Törnqvist index is often examined and used. Törnqvist index (Törnqvist, 1936) makes use of logarithms for comparing two entities (for example two economies) or for comparing a variable in regards to one entity at two points in time. When used to compare inputs for two time periods, in the context of productivity measurement, it employs an average of cost-share weights for the two periods being considered (Dean, Edward T. et al., 1996). Törnqvist index values of two periods are strung together or chained, hence Törnqvist index is a chained index that doesn't refer to a single base year.

III. DATA

The study uses primary and secondary data collected from the Indonesian Bureau of Statistics (BPS) and case study in Riau Province, Indonesia. The study uses Tornqvist-Theil index which measures changes in the real economy and avoids the index number bias arising from the use of fixed weights in input and output aggregation (Fuglie, 2010).

In this study, data used are output and inputs from year 2000 onwards, period where Indonesia's CPO productivity per unit area increased dramatically. *Total CPO yield* of Riau Province over the span of a few years are used to compute the output index. The measurement unit of this output is in tons. *Labor*, *farm machinery*, *pesticides*, *fertilizers*, and *land* are used to compute the input indexes (USDA 2013).

IV. METHODOLOGY

Palm oil TFP is measured as the ratio of total outputs to total inputs, calculated using Tornqvist-Theil index. Chained index method is used because in the process of economic development, cost shares of capital and material input tend to rise while cost shares of labor tend to fall. Tornqvist price index is expressed as follows.

$$ln\frac{P_t}{P_{t-1}} = \frac{1}{2}\sum_{i=1}^{n}\left(\frac{p_{i,t-1}q_{i,t-1}}{p_{t-1}q_{t-1}} + \frac{p_{i,t}q_{i,t}}{p_t q_t}\right) ln\left(\frac{p_{i,t}}{p_{i,t-1}}\right) \quad (2)$$

Where
P_t = Tornqvist price index at time t,
p_t = price at time t,
q_t = quantity at time t,
n = number of goods.

Equation (1) which shows that TFP is ratio of total outputs to total inputs. Changes in TFP over time are found by comparing the rate of change in total output with the rate of change in total input. Expressed as logarithms, changes in TFP over time can be written as follows.

$$\frac{d\ln(TFP)}{dt} = \frac{d\ln(Y)}{dt} - \frac{d\ln(X)}{dt} \quad (3)$$

Considering agricultural productivity is a multi-output, multi-input production process, *X* and *Y* become vectors. Producers try to maximize revenue, so for example, if there is an increase in cost shares of input, revenue will also experience an increase until it reaches equilibrium. Therefore equation (3) can be written as follows.

$$\ln\left(\frac{TFP_t}{TFP_{t-1}}\right) = \sum_{1} R_i \ln\left(\frac{Y_{i,t}}{Y_{i,t-1}}\right) - \sum_{j} S_j \ln\left(\frac{X_{j,t}}{X_{j,t-1}}\right) \quad (4)$$

Where
TFP = total factor productivity,
Y = total outputs,
X = total inputs,
R_i = revenue share of the ith output,
S_j = cost-share of the jth input.

V. EXPECTED OUTPUT

The expected output of this study is TFP indexes from the year 2000 to 2018. Furthermore, input and output indexes growth can also be observed.

An example output from dataset obtained from a previous research (Nuryantono, 2016) is shown below.

Table 1. Input and output data from crude palm oil production in District of Muaro Jambi, Jambi Province (Nuryanto, et. al., 2016).

	Land		Pesticide		Fertilizer		Labor		Output (tonnes)
	q (Ha)	p (IDR)	q (litre)	p (IDR)	q (Kg)	p (IDR)	q (day)	p (IDR)	
2009	36.9	2003046	117	70000	16250	2524	236	60000	487.18
2012	31.7	3283410	77	70000	16524	3451	310	75000	560.01

From the table above, using the research methodology explained in the previous chapter, the following result is obtained.

Table 2. Input, output, and TFP calculation results of crude palm oil production in Muaro Jambi (author's analysis based on Nuryanto, et. al., 2016).

Year	Output index	Input index	TFP index
2009	1.0000	1.0000	1.0000
2012	1.1495	0.8976	1.2807

From table 2, it's apparent that while output only increased by 14%, Total Factor Productivity in 2012 increased by 28% compared to 2009. It indicates that even though there are decreases in some inputs, they are being used quite efficiently to produce more output.

The next step in this research is to use real data from high productivity plantations in Indonesia. Fluctuations observed in input and output indexes can be attributed to technical change, change technical efficiency, and/or shift in managerial ability which affects scale and mix efficiency.

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