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Total Factor Productivity Analysis of Oil Palm Production in Indonesia

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ABSTRACT

Over the last few decades, Indonesian oil palm industry has grown significantly becoming a very important agriculture-based industry, where the country is today the first world's leading producer and exporter. Total factor productivity (TFP) is a framework that can be employed to analyze the source of economic growth. Using the data from the National Farmers Panel Data Survey for the year 2009 and 2012 in two observed districts respectively in Sanggau and Muaro Jambi district, the results of determinant factors analysis shows that *Land*, *Pesticide*, *Fertilizer* and *Labor* have significant contribution to total production of oil palm in both districts. On the other hand, based on accounting approach, the result reveals that TFP index values of the districts of Sanggau and Muaro Jambi respectively were 1.56 and 1.03. This study have important implications on how to facilitate the adjustment of small farmers to more efficient oil palm production.

Keywords: Oil Palm, Total Factor Productivity, Indonesia
JEL Classifications: D24, O3, O33, Q12

1. INTRODUCTION

Over the last few decades, Indonesian oil palm industry has grown significantly becoming a very important agriculture-based industry, where the country is today the first world's leading producer and exporter. Since the early of 1960s, the expansion of the industry started as a part of government's diversified cautious policy from rubber to oil palm and also a tool to raise the socio-economic status of the expanding population in the country. Indonesia stands in the first place in global oil palm producers with total production reached to 27 million tonnes replacing Malaysia (19.22 million tonnes) which previously standing as the first. The triumph also happens in terms of global oil palm exporters. Indonesia is blessed with favorable weather conditions which prevail throughout the year of which is advantageous for oil palm cultivation. In the 1970s, the government of Indonesia initiated major programs to expand estate crop production, especially in sparsely populated regions of Sumatera, Borneo, Sulawesi and Papua. The program schemes were especially important for the oil palm industry, which greatly expanded after 1980. By 1999, oil palm became the dominant estate crop, surpassing both rubber and coconut in total area planted.

In the first decades when oil palm expansion firstly started, the production were only less than one million tonnes but showed to have increased year by year. The exponential trend of oil pam yields showing that oil palm production in Indonesia is increasing sharply in yoy basis. The sharply increases were stimulated by government's active expansion in New Order era especially when the price of oil palm in the international market was exceptionally high in 1974, well-known as Perkebunan Inti Rakyat or Nucleus Estate program (Santosa, 2007).

The crop has also played a significant role in the socioeconomic development of rural areas by providing employment and raising the income level. Oil palm is the raw material of food processing industry, cosmetics industry, chemical industry and even for those which use the raw materials of crude oil palm. In addition, oil palm industry is an important contributor to the country's gross domestic product (GDP). In 2013, Indonesia's oil palm production was up to 27 million tonnes. According to BPS Indonesia (2013), the total volume of exports of oil palm in 2007 accounted to 13.21 million tonnes with a total value of exports amounted to US $8.87 billion and increased to 22.22 million tonnes in 2013 with a total value of US $17.14 billion.

Total plantations area, according to the General Directorate of Estate Crops of Indonesia (2015), is also likely to show improvement over the last 5 years. As in 2010, Indonesian oil palm plantations covered an area of 8.38 million hectares and recorded to have increased to 11.44 million ha in 2015. In general, the structure of Indonesian Oil Palm Production in 2010-14 is depicted in Table 1.

2. LITERATURE REVIEW

The production function can be expressed in a variety of ways such as the form of writing, summation, and description of input which is capable of generating input; by registering input and produce a number of outputs in the table; in the form of charts or graphs; and algebraic functions. Symbolically, the production function can be written as follows:

$$Y = f(X_1, X_2, X_3, \ldots, X_n) \quad (1)$$

Where, Y is output and $X_1 \ldots X_n$ are different inputs which have a role to produce Y. The symbol f indicates the relations that transform inputs into outputs. For every combination of input, it will generate a several unique outputs. For example, Y may represent yields of oil palm; X_1, the amount of used pesticide; X_2, the amount of used fertilizer; etc. Meanwhile, couple of production functions that often used are classical production function and Cobb-Douglas production function.

Meanwhile, the Cobb-Douglas function explains that output is the function of capital and labor as often used in mostly empirical studies (Salvatore, 2006). The function can be expressed as follow:

$$Q = AL^{\alpha}K^{\beta} \quad (2)$$

Where,

Q = Output,
L = Labor force,
K = Capital.
α and β = Positive parameters of each variable.

The function describes that the greater the value of A, the more advanced technology. The parameter α measures the increase percentage in Q due to the increase of one percent of L while K is kept constant. Similarly, β measures the increase percentage in Q due to the increase of one percent of K while L is kept constant.

However, there are couple of weaknesses of Cobb–Douglas function, according Debertin (1986) the weaknesses are: (1) There is no maximum production of (y), which means that all combinations of inputs (x) that increase the production of (y) will continue to rise along the path of its expansion, and (2) the elasticity of production remains. This weakness makes Cobb–Douglas production function cannot describe the neoclassical production function.

The necessary ingredients for an assessment of agricultural productivity are measures of aggregate outputs and inputs and their economic values (Alston et al., 2010). The growth rate in agricultural output or agricultural GDP is estimated by taking agricultural output net of feed and seed, valued at current national prices, and then subtracting payments for materials provided by other sectors (e.g., fertilizer, chemicals, and energy).

The Food and Agricultural Organization (FAO) divided inputs into five categories. Farm labor is the total economically active adult population (males and females) in agriculture. *Agricultural land* is the area in permanent crops (perennials), annual crops, and permanent pasture. Cropland (permanent and annual crops) is further divided into rain-fed cropland and cropland equipped for irrigation. *Livestock* is the aggregate number of animals in "cattle

Table 1: The structure of Indonesian oil palm production in 2010-2014

Indicators	2010	2011	2012	2013	2014
Agricultural GDP (billions of 2000 constant price of rupiahs)	304,777.1	315,036.8	328,279.7	339,560.8	350,722.2
Share of agricultural GDP (percent)					
Food crops	49.7	48.9	48.4	47.7	46.8
Estate crops	15.5	15.6	15.9	16.1	16.3
Livestock and its product	12.5	12.7	12.8	12.9	13.1
Forestry	5.7	5.5	5.3	5.1	5.0
Fishery	16.6	17.2	17.6	18.2	18.8
Estate crops output (millions tonnes)					
Oil palm	22.50	23.98	26.02	27.78	29.34
Coconut	317.44	322.81	2.94	3.05	3.03
Rubber	273.49	299.02	3.01	3.24	3.15
Sugarcane	228.87	224.42	2.59	2.55	2.58
Cocoa	83.79	71.22	0.74	0.72	0.71
Oil palm total crop land (millions hectares)	8.38	8.99	9.57	10.46	10.96
Labors in oil palm plantation (million workers)	3.37	3.65	3.76	5.18	5.43

Sources: Agricultural GDP, shares of Ag GDP, and estate crops output are from BPS (Statistics Bureau of Indonesia). Oil palm total crop land and labors are from General Directorate of Estate Crops of Indonesia. GDP: Gross domestic product equivalents" held in farm inventories and includes cattle, camels, water buffalos, horses and other equine species (asses, mules, and hinnies), small ruminants (sheep and goats), pigs, and poultry species (chickens, ducks, and turkeys), with each species weighted by its relative size. The weights for aggregation based on Hayam and Ruttan (1985. p. 450) are as follows: 1.38 for camels, 1.25 for water buffalo and horses, 1.00 for cattle and other equine species, 0.25 for pigs, 0.13 for small ruminants, and 12.50 per 1000 head of poultry. *Fertilizer* is the amount of major inorganic nutrients applied to agricultural land annually, measured as metric tons of N, P_2O_5, and K_2O equivalents. *Farm machinery* is the number of riding tractors in use.

Moreover, Hayam and Ruttan (1985) hypothesized that countries with different resource endowments would follow different paths of technological development in agriculture. Population-dense (land-scarce) Asian countries would develop and adopt land-saving technologies like high-yielding crop varieties.

Oil palm is originally an African crop, which was introduced to South East Asia in the 19th century. Since the South East Asia region is blessed with favorable weather conditions which is advantageous for oil palm cultivation, thus, it is not surprising that most oil palm is currently produced in South East Asia and the highest yields have been obtained from palms grown in this region even though it is far from its natural habitat.

Oil palm is one of alternative energy plants that has high economic value. Nearly all parts of the plant oil palm and further processing can be used for various purposes. Oil palm has many advantages compared to other vegetable oils either from the aspect of the diversity of products that can be produced, aspects of nutrition, health, productivity, efficiency and price which is very competitive. Based on those advantages, it helps the commodity to meet the needs of the nation and global demand. It also helps the business in developing oil palm production and processing from the upstream to downstream sector which in line to support the diversification of energy sources. With a rapidly growing world population, the demand for oil palm is increasing especially for many industries related to energy, food and non-food products. In 2010, oil palm accounted for 36.5% of the world's vegetable oil production and it is projected to be the leading vegetable oil in the world by 2016 (Choong and McKay, 2014).

Oil palm seedlings are typically raised in a nursery for 1 year before planting out. Planting densities range from 110 to 150 stems/ha (Sheil et al., 2009). Palms mature rapidly and fruit can be harvested as soon as 2-3 years after planting (Basiron, 2007), although trees aged 9-15 years are the most productive (BisInfocus, 2006). After 25-30 years, trees become too tall to harvest 7 and are replaced. With appropriate management, plantations can be productive on a wide range of soils, including "problem soils" such as acid sulphate soils, deep peat and acidic high aluminium soils, where few other crops are successful (Auxtero and Shamshuddin, 1991).

Compared to other major oil crops, palm oil has lower production costs and produces more oil from less land (Yusoff and Hansen, 2007). Returns on land, capital and labor produce substantial revenues both for companies and for countries. Oil palm can be an attractive crop for smallholders. If they can make the necessary initial investments and survive the 2-3 unprofitable years before their first harvest, smallholders can get good returns on very limited labor and low inputs of fertilizer, suggesting possible benefits from oil palm in less intensive and in mixed production systems (Sheil et al., 2009).

In Indonesia, the production of oil palm is increasing from year to year. Since 1961, the average growth oil palm is around 11.77% per year (FAOSTAT, 2015). The development of oil palm production also absorbs a lot of labor force. With the composition of oil palm total area reached 10.9 million ha in 2014, the oil palm industry and its supporting industries have provided job opportunities for more than 5.4 million workers (Oil Palm Plantations Statistical Book of General Directorate of Estate Crops of Indonesia, 2014).

Moreover, given a great potential labor source, very supportive, suitable climate and vast land natural conditions, Indonesia is running to continue to develop the oil palm industry. With the potential level of production, Indonesia is known as the country's second largest major exporter of oil palm in the world after Malaysia.

Total factor productivity (TFP) is usually defined as the ratio of aggregate output to aggregate input (i.e., as the average product of aggregate input). If total output is growing faster than total inputs, then it is called an improvement in TFP. It is necessary to account somehow for the sum total of changes of services of land, labor, capital, and material inputs used in production. Moreover, TFP is measured as the residual part of the movement in output left unexplained by major fact inputs or as a preferred measure of productivity compared with partial productivity (Solow, 1957; Jorgenson, 1995). Fuglie (2010) also interpreted that TFP as a measure of the gain in efficiency with which inputs are used, including technological progress.

Fuglie (2010) estimated TFP in the Global Agricultural Economy between 1961 and 2007. He found that in developed countries, TFP continued to rise but the rate of growth in 2000-07 was under 0.9% per year, the slowest of any decade since 1961 while in developing countries productivity growth accelerated in the 1980s and the decades following. Input growth steadily slowed but was still positive. His study marked contrast to the early findings of Hayam and Ruttan (1985) and Craig et al. (1997), which found developing countries to be falling further behind developed countries in agricultural land and labor productivity. On his other study, Fuglie (2010) also found that Indonesia achieved an annual growth rate in agricultural production of 3.6% over the 1961-2006 period using the Tornqvist-Thiel index method. The study also resulted that TFP in agriculture accelerated during the green revolution period (1968-1992) but then TFP growth stagnated in 1990s and did not resume until recovered from Asian Crisis in 1997.

Using the same Tornqvist method (Karunakaran, 2014) shows that the performance of the crop sector in Kerala, at the state level and district level measured in terms of TFP growth, indicated a whole registered negative growth rates during the period 1980-81 to

2009-10. He also found that TFP index in the state showed negative growth rate due to relatively high growth of input use compared to that of output index. Coelli et al. (2003) mentioned that technology and agricultural research expenditure were the important driver for TFP change in Bangladesh Crop Agriculture. While Li et al. (2015) found in China that production growth in Chinese Agriculture due to either technology progress or efficiency gain. Both factors were not simultaneously affecting productivity growth.

Meanwhile, Suphannachart and Warr (2010) using Conventional Growth Accounting Method showed on their study that TFP makes an important contribution to both crop and livestock output growth over the study period of 1970-2006. Specifically, TFP accounts for about 21% of crop output growth and 17% of livestock output growth. These TFP growth measures are converted into a TFP index level and are used as the dependent variables in the subsequent TFP determinants models.

3. DATA

The study used secondary data and was collected from the National Farmers Panel Data Survey conducted by the Bureau for Social Economic and Policy, and Agricultural Development Research Agency in 2009 and 2012.

This study was employed using Tornqvist-Theil index. The Tornqvist-Theil index of output, input, and productivity are measures of changes in the real economy and avoid the index number bias arising from the use of fixed weights in input and output aggregation (Fuglie, 2010). The Tornqvist-Theil index has been also widely used in the measurement of the TFP index (McClellan, 2004) and is used in the present study for measuring the TFP indices for the crop sector by districts and state.

In this study, the total production of oil palm in two districts was used to compute the output index where *Land, Pesticide, Fertilizer*, and *Labor* were incorporated into the model as explanatory variables to construct the total input index. Oil palm production as the total output measured in tonnes. *Land* is acquired by the total area of oil palm plantation that each household has, figures are given in total hectares. *Pesticide* is the total of litre amount of active ingredients of chemical pesticide plantation such as fungisides, herbicides, insectides and other chemicals consumed in oil palm plantation. *Fertilizer* is referred to the amount of applications of chemical fertilizers (N, P_2O_5, and K_2O) to oil palm land in each year, measured in tonnes. Due to the limited data of adult population involved in the plantation, *Labor* is acquired by applying the total economically active working days of adult population (males and females, either coming from household members or paid workers from outside the household).

4. METHODOLOGY

TFP is occupied to measure the productivity of oil palm. We measured oil palm TFP as the ratio of total output to total inputs of the sector. The first step of this method is calculating the total index of production factors using Tornqvist-Theil index (Caves et al., 1982):

$$\ln\left(X_t / X_{t-1}\right) = \sum_j \frac{1}{2}\left(S_{jt} + S_{jt-1}\right)\ln\left(X_t / X_{t-1}\right) \quad (3)$$

$$S_{jt} = R_{jt}X_{jt} / \sum_j R_{jt}X_{jt} \quad (4)$$

Where,

X_t = TFP at time *t*,
X_{jt} = Value of production factor *j* at time *t*,
S_{jt} = Share of expenditure to production factor *j* in the total cost at time *t*,
R_{jt} = Price of production factor *j*.

In order to equalize the equation at the same level, the discrepancy of time variant needs calculation upon constant price. By setting the index numbers at the base year 100 (base year used is 2009 and it can be assumed 2009 = 100), then the total chain index of production factors and production output is calculated as follows:

$$IX_t = X_t/X_{t-1} \quad (5)$$

$$IY_t = Y_t/Y_{t-1} \quad (6)$$

Where,
X_t = Total value of production factors (inputs) at time *t,*
Y_t = Total value of production (output) at time *t,*
IX_t = Total production factors (inputs) index at time *t,*
IY_t = Total production (output) index at time *t*,
Hence, the TFP index can be calculated as follow:

$$TFP_t = IY_t/IX_t \quad (7)$$

In this study, we also occupied a further measurement in order to analyze factors that affecting the oil palm production. We used multiple linear regression analysis to analyze the affecting factors. The determinant model of production incorporates all factors that affect oil palm productivity in this study. However, according to data availability and objectives of this study, the statistical analysis is based on a conceptual model with the incorporated explanatory variables; *production (output)*, *Land*, *Pesticide*, *Fertilizer*, and *Labor*. Therefore, in stylized form, the estimated model of determinant factors of oil palm production is as written below:

$$Y_t = \alpha_{it} + \beta_1 A_t + \beta_2 P_t + \beta_3 F_t + \beta_4 L_t, \varepsilon \quad (8)$$

Where,
Y_t = Total output (production) value at time *t* (ton),
A_t = Total quantity of land at time *t* (hectare),
P_t = Total quantity of pesticide at time *t* (litre),
F_t = Total quantity of fertilizer at time *t* (kilogram),
L_t = Total quantity of labor at time *t* (working day),
e = Error term.

In order to see the consistency of the first model in equation, there will be addition of other two models in this study. Almost the same as the first model, the other two models are not much different. The second model is the modification of first model of which the dependent variable (total output) is in the form of natural logarithm. This model is called semi log model. The use justification of this model is merely on the assumption of difference in terms of change in which the change in output might be greater than the change in output. According to Hardy (1993), the interpretation of the coefficient of the variable (δ) in semi log model is adjusted with the base natural log (e = 2.718) which is equal to (e^{δ}−1) (100). In statistical form, the second model can be written as follow:

$$\ln Y_t = \alpha_{it} + \beta_1 A_t + \beta_2 P_t + \beta_3 F_t + \beta_4 L_t, \varepsilon \quad (9)$$

The third model is a natural logarithms function of the first model in which both dependent variable and independent variables were adjusted into natural logarithms form. The use justification of this model is based on the assumption that for changes in both output and input are on the same level which is in elasticity function. The third model function can be expressed as follow:

$$\ln Y_t = \alpha_{it} + \beta_1 \ln A_t + \beta_2 \ln P_t + \beta_3 \ln F_t + \beta_4 \ln L_t, \varepsilon \quad (10)$$

5. RESULT AND DISCUSSION

5.1. TFP Measurement of the District of Sanggau, West Borneo Province

Oil palm farming in the district of Sanggau, West Borneo, uses some production factors consisting land, seeds, pesticide, fertilizer and labor for cultivation and harvesting needs. The TFP was measured by calculating the average rate of all variable items growth with base growth (2009 = 1). The method applied to measure factor share of variable items was by dividing the variable item value with total factor value. In this analysis, harvesting and transporting equipment grouped on the use of other types of input.

The analysis result of Table 2 showed that TFP index value of the district of Sanggau was 1.56 interpreting that there was an increasing in TFP by 56% from 2009 to 2012 by assuming that TFP in 2009 is at the base level 1. In other words, oil palm production in 2012 was 56 percent more productive than in 2009. However, yield shows to have increased from 748.16 tonnes to 1127 tonnes or increased by 50.6%. The Table 2 also depicts the dynamic growth of each production input (in nominal altitude) refer to total input production share. Based on the share, inputs that had increased from 2009 to 2012 are *Land* which had increased by 49%, *Pesticide* by 26% and *Fertilizer* by 40%. Meanwhile, *Labor* showed declining by 18%. Based on these numbers, the most important reason for the increasing input share in *Land*, *Pesticide* and *Fertilizer* and decreasing *Labor* share in oil palm production in this areas is confirmed to the consequence of oil palm tree age which says that for younger trees production will be more focused on inputs intensification until the trees become mature and more productive in harvesting (BisInfocus, 2006). This condition actually supports the hypothesis of USDA (2014) that in developing countries, agricultural resources (except labor) continue to expand and at the same time the productivity of these resources is improving.

5.2. TFP Measurement of the District of Muaro Jambi, Jambi Province

In general, oil palm farming in the district of Muaro Jambi, Jambi, uses the same production factors as the case happened in the district of Sanggau, West Borneo, for the needs of cultivation and harvesting of the area.

The analysis result of Table 3 showed that TFP index value of the district of Muaro Jambi was 1.03 interpreting that there was increase in TFP by 0.03% from 2009 to 2012 in the district by assuming that TFP in 2009 is at the base level 1. In other words, the production of oil palm in 2012 is 3% more productive than the production in 2009. This implies that even though the TFP result has not grown rapidly at that time, but the district of Muaro Jambi could attain positive TFP growth about 3% of their expected output from the available inputs.

In the analysis, yield also increased from 487.18 tonnes to 560.01 tonnes or increased by 14%. The Table 3 also depicts the dynamic growth of each production input refer to input share respectively in nominal altitude. Based on the result, input that had increased was only *Labor* (8%). This increase signals to the consequence of oil palm tree age which had been described previously that the older the oil palm trees especially those which are in 16-25 years will increase the productivity in *Labor* as more *Labor* will be more needed than other inputs in terms of harvesting. Otherwise, other inputs had experienced declining, respectively *Land* (6.4%), *Pesticide* (58%) and *Fertilizer* (7.7%). This supports the explanation that for mature stage oil palm plantation, any use in other inputs except *Labor,* will be less utilized. However, from the

Table 2: Tornqvist-Thiel TFP measurement result of oil palm in 2009 and 2012 in the district of Sanggau

Productivity	*Land* (A)		*Pesticide* (P)		*Fertilizer* (F)		*Labor* (L)		Cost (Rp)	Output
	X_1 (Ha)	W_1 (Rp)	X_2 (L)	W_2 (Rp)	X_3 (kg)	W_3 (Rp)	X_4 (Wd)	W_4 (Rp)		(Ton)
2009	42.1	1,757,365	91.76	75,000	12.98	4,224.20	6.33	52.7	469,183,950	748.16
2012	42.0	2,827,315	124.42	75,000	19.10	4,329.62	5.45	53.6	502,745,500	1127
Share	***Land* (A)**		***Pesticide* (P)**		***Fertilizer* (F)**		***Labor* (L)**		**Total share**	
2009	0.158		0.015		0.117		0.711		1	
2012	0.236		0.019		0.164		0.581		1	
Ln output index			0.41							
Ln input index			−0.04							
Ln TFP index			0.45							
TFP index			1.56							

Number of observation=22 households with the average landholding 1.91 Ha. Source: Author's estimates using PATANAS household data of 2009 and 2012. TFP: Total factor productivity

Table 3: Tornqvist-Thiel TFP measurement result of oil palm in 2009 and 2012 in the district of Muaro Jambi

Productivity	*Land* (A)		*Pesticide* (P)		*Fertilizer* (F)		*Labor* (L)		Cost (Rp)	Output
	X_1 (Ha)	W_1 (Rp)	X_2 (L)	W_2 (Rp)	X_3 (Kg)	W_3 (Rp)	X_4 (Wd)	W_4 (Rp)		(Ton)
2009	36.9	2,003,046	117	70,000	16,250	2524	2.36	60,000	264,531,226	487.18
2012	31.7	3,283,410	77	70,000	16,524	3451	3.10	75,000	399,325,800	560.01
Share	***Land* (A)**		***Pesticide* (P)**		***Fertilizer* (F)**		***Labor* (L)**		**Total share**	
2009	0.279		0.031		0.155		0.535		1	
2012	0.261		0.013		0.143		0.583		1	
Ln output index			0.14							
Ln input index			0.11							
Ln TFP index			0.03							
TFP index			1.03							

Number of observation=17 households with the average landholding 2.17 Ha. Source: Author's estimates using PATANAS household data of 2009 and 2012. TFP: Total factor productivity

analysis above, it is shown that the use of production inputs (TFP) had increased yet not all production inputs experienced increasing in term of their productivity.

5.3. Determinant Factors of Oil Palm Production

The econometric approach helps to analyze the determinant factors that affecting the production (yield) of oil palm. The econometric approach result was generated using multiple linear regression models by pooling combined household data of Sanggau and Muaro Jambi districts in 2009 and 2012 with 72 observations.

The determinants model above is statistically significant at the 1% level in terms of the F test. The equation passes all the standard diagnostic tests. The factors affecting production of oil palm in both districts are *Land*, *Pesticide* and *Labor*. *Land* is statistically significant at the 1% level interpreting that an increase in land of 1 ha leads to an increase in oil palm production of 3.78 tonnes. *Pesticide* has a positive and significant impact on oil palm production as a 1 litre increase in *Pesticide* results an increase in oil palm production of 0.46 ton. The result shows that *Fertilizer* is not statistically significant yet has positive estimated coefficient. However, this indicates that there is no enough evidence to prove that *Fertilizer* significantly influences production in this model. Labor is also statistically significant at the level of 1% which means an increase of 1 day working day would lead an increase in oil palm production of 0.34 ton.

The model in Table 4 is statistically significant at the 1% level in terms of F-test. Model 2 represents the semi log function, assuming the change in output might be greater output than the change in output. Production as dependent variable is formed in natural logarithm while the remaining formed in quantity value. The function passes all the standard diagnostic tests. All variables are statistically significant and it is justifiable to influence the production of oil palm in both districts. The interpretation of the coefficient of the variable (δ) with the base natural log (e = 2.718) is equal to (e^{δ}−1) (100) (Hardy, 1993). *Land* is statistically significant at the 1% level interpreting that with a 0.56 coefficient of variable *Land* resulting in 75% of oil palm production. *Pesticide* has a positive and significant contribution at the level of 10% on oil palm production interpreting that with a 0.44 coefficient of variable *Pesticide* resulting in 55% of oil palm production. *Fertilizer* is statistically signed at the

Table 4: Multiple linear regression of oil palm production determinants in the Districts of Sanggau and Muaro Jambi 2009 and 2012 (Model 2)

Variable	Coefficient	Standard error	t	P>|t|
Land	3.782***	1.078	3.51	0.001
Pesticide	0.461*	0.026	1.76	0.083
Fertilizer	0.001	0.001	0.52	0.606
Labor	0.347***	0.008	4.55	0.000

R^2=0.8172. The level of statistical significance is denoted as: *10%, **5% and ***1%

level 5% indicating that with a 0.0002 coefficient of variable *Fertilizer* resulting in 0.019% of oil palm production. *Labor* is also statistically significant at the level of 1% which explains that with a 0.004 coefficient of variable *Labor* resulting in 0.04% of oil palm production in both districts.

The model above is statistically significant at the 1% level in terms of F-test. Model 3 represents the natural logarithms equation, assuming that changes in both output and input are on the same level which is in elasticity function. All variables are measured in natural logarithms. Since all variables are measured in logarithms, the regression coefficients can be interpreted as elasticities and the size of the coefficients also indicate the magnitude of their relative influence. The equation passes all the standard diagnostic tests. The factors affecting production of oil palm in both districts are *Fertilizer* and *Labor*. *Fertilizer* is statistically significant at the 5% level interpreting that an increase in *Fertilizer* of 5% leads to an increase in oil palm production of 0.12%. *Labor* also has a positive and significant impact on oil palm production as a 1% increase in *Labor* results an increase in oil palm production of 0.42 percent. *Land* and *Pesticide* have negative coefficients and are not statistically significant indicating that it does not have enough evidence to prove that *Land* and *Pesticide* significantly influence production in this model.

According to the results, the best model goes to Model 2. The decision is made comparing the results of each model to the given previous studies saying that the younger the trees the more intensified production would be (BisInfocus, 2006) where adaption of input varieties, such as *Land, Pesticide, Fertilizer* and *Labor* primarily play an important role in securing higher yields (Fuglie, 2010). By assuming that in 2009 and 2012 the trees in both districts were still at the productive ages, it can

Table 5: Multiple linear regression of oil palm production determinants in the Districts of Sanggau and Muaro Jambi 2009 and 2012 (Model 1)

Variable	Coefficient	Standard error	t	P>|t|
Land	3.782***	1.078	3.51	0.001
Pesticide	0.461*	0.263	1.76	0.083
Fertilizer	0.001	0.001	0.52	0.606
Labor	0.347***	0.008	4.55	0.000

R^2=0.8172. Note: The level of statistical significance is denoted as: *=10% and ***=1%

Table 6: Natural logarithm regression of oil palm production determinants in the Districts of Sanggau and Muaro Jambi 2009 and 2012 (Model 3)

Variable	Coefficient	Standard error	t	P>|t|
ln_*Land*	−0.163	0.137	−1.19	0.239
ln_*Pesticide*	−0.013	0.091	−0.14	0.886
ln_*Fertilizer*	0.126**	0.060	2.09	0.042
ln_*Labor*	0.422***	0.070	6.02	0.000

R^2=0.9835. The level of statistical significance is denoted as: **5% and ***1%

be said that the use in *Land, Pesticide, Fertilizer* and *Labor* were important to production and any insignificance of these given factors in the models will be ignored as the best model. The result of Table 5 portrays insignificant factor of *Fertilizer* while in Table 6 there were two insignificant factors, *Land* and *Pesticide* which is very impossible to do production if there is no *Land*, *Fertilizer* and *Pesticide*. As the consequences, Model 1 and Model 3 fail to give best estimation. Therefore, the best model goes to Model 2 where the estimation successfully proves that all the factors are significant to oil palm production in both districts. However, since TFP is also known as the residual part of the use of technology, in this case the referred existence is reflected by *Fertilizer*. *Fertilizer* does not only play a major role as a part of intensification of input use but also as non-advanced machinery technology and the significance of the variable captured the sign of TFP occurrence.

6. CONCLUSION

The ongoing expansion of oil palm plantations in the humid tropics, especially in Indonesia, is generating more considerable concern and serious debates recently. There are also sustainability issues raised on the stage including environmental, social, and economic aspects of the global strategic issues. The ongoing issues have sparked a variety of risks that can harm various parties. Some of the risks that can arise are land disputes, environmental pollution, forests conversion and loss. Losses incurred are not only experienced by the company but also experienced by farmers, investors, and other stakeholders. Accordingly, these sustainability issues need to be managed properly to ensure oil palm supplies. Therefore, considering the future production prospectus and policy implications of oil palm plantations, we need to conduct such an evaluation estimation.

TFP is one of evaluation measurements to see the gain in efficiency of which inputs are used, including technological progress and technical efficiency. Using combined pooled household data of oil palm production in district of Muaro Jambi, Jambi Province and district of Sanggau, West Borneo Province in year 2009 and 2012, the results had discovered that during the given time TFP of oil palm in both areas increased respectively by 56% and 3% which indicating that the production of oil palm in 2012 is more productive than in 2009.

However, the determinant factors analysis of TFP shows that variable *Land* still takes a major role in oil palm production in both districts, showed by its second biggest share. This fact shows that oil palm production still depends on land existence to produce more. However, land expansion in oil palm production cannot go continuously regarding the tendency of degradation and forests loss due to land extensification. Besides, based on the results, other variable inputs also play important role to be considered in oil palm production. The TFP measurement has shown that *Pesticide, Fertilizer* and *Labor* also had significant contribution to total production of oil palm in the district of Muaro Jambi and district of Sanggau in 2009 and 2012. This finding encourages to not leave behind the importance of these input substantives as factor inputs in oil palm production. This is also in line with Hardter et al (1997) which suggests not to ignore such non-land inputs and to have better management, higher yields from improved varieties and planting on land that is already degraded which could improve yields significantly without further deforestation. Eventually, the results of this study expect the likelihood of oil palm to shift from land extensification to inputs intensification (fertilizer, pesticide and high labor absorption). Not to mention, this pattern will expectedly help increasing workers social welfare especially farmers.

In general, this research encourages producers, from any backgrounds, to strongly conduct TFP measurement in order to see the efficiency and effectiveness of any used input variables since TFP is essential to measure production of which the result is expected to have a better production projection in the future. Any compound inputs seem to relatively influence production, therefore it is really mandatory to have in-depths look for any inputs use. However, along with the significant contribution of non-land inputs in oil palm production, it is suggested to have improvement on inputs intensification instead of letting massive land expansion.

The results of this study also have important implications for policymakers on how to facilitate the adjustment of small farmers to an efficient oil palm production. Oil palm farmers in Indonesia have to learn how to obtain efficient production in order to increase their social welfare. Moreover, for further research, it is suggested to have a complete data especially for input variable seed and machinery which are not incorporated in this study due to the incompleteness of the data in order to have more comprehensive results and better policy implications.

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