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Intensity of Oil Palm Technology Adoption on Pir Partnership and Self-Help in Riau and West Kalimatan

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Abstract – This study specifically examined the rate of adoption, and the factors that influence the adoption of FFB production technology by smallholders in Riau and West Kalimantan. This study used secondary data from the 2014 plantation household survey, which was conducted by the Central Bureau of Statistics (BPS). The data used was the cross-section data with the 2014 time frame. The criteria for the data used in this study was the yielding plants (TM). In Riau data of farmers used were 1915 farmers and in West Kalimantan data of farmers used were 546 farmers, which a total of 2461 farmers. This study concluded that for smallholder oil palm farmers who increase the intensity of technology adoption, their productivity also increases. Therefore, farmers who adopt all palm oil technologies, they are more productive than farmers who do not adopt or only adopt some of the technologies. Palm oil productivity in Riau and West Kalimantan has increased along with the increase in technology adopted. In Riau, the type of management, KUD membership, farmer group members, assistance and farmers' income were the main factors that significantly influenced the intensity of technology adoption. Whereas in West Kalimantan the main factors that significantly influenced the intensity of technology adoption were assistance and farmer group membership.

Keywords – Oil Palm, Technology Adoption, Riau and Kalimantan Barat.

I. INTRODUCTION

The increasing global demand for vegetable oils, biofuels and industrial materials (McCarthy 2010) has led to an increase in oil palm plantation areas in many tropical countries in the past decade (Schwarze et al. 2015). The total production of crude palm oil (CPO) has more than quadrupled, so palm oil is the most produced and traded vegetable oil commodity in the world (Euler et al. 2016). In addition, the potential advantages of oil palm compared to other alternative oil crops are the most efficient raw materials for biofuels because they have low production costs (Mol 2007; Tan et al. 2009; Euler et al. 2016).

As the world's largest palm oil producer, Indonesia has a relatively lower productivity level compared to other major

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palm oil producing countries. The rapid rate of expansion of smallholder oil palm plantations in Indonesia is compared to the company's oil palm plantations because most oil palm farmers prefer to expand their oil palm land area (extensification) to achieve higher output (Lee et al. 2014; Alwarritzi et al. 2016).

In general, we can distinguish smallholder farmers into two types, namely farmers with PIR partnership patterns and self-help farmers. PIR partnership farmers are farmers who start oil palm cultivation with management schemes under government or private guidance and for the second, those who decide to adopt oil palm management independently (Euler et al. 2015).

The basic principle of this research is to find out how farmers who adopt recommended technology in full and farmers who do not adopt or only adopt a part of the recommended technology to the level of productivity. And then to understand the factors that influence it. Thus the objectives of this study are: (1) to compare the intensity of technology adoption in smallholder oil palm plantations between PIR partnership and self-help patterns (2) to analyze factors that influence the technology adoption rate and (3) analyze the effect of intensity of technology adoption on smallholder palm oil productivity.

II. Research Method

This research was carried out using secondary data from the 2014 plantation household survey, which had been carried out by BPS (Central Bureau of Statistics). The data used in this study selected 2 smallholder oil palm center provinces, namely Riau and West Kalimantan with a total of 2461 plantation households, consisting of 1915 households from Riau and 546 households (from West Kalimantan. When viewed based on management patterns, consisting of PIR partnership patterns as many as 603 households and self-help patterns as many as 1858 households, the majority of smallholder oil palm farmers in Riau (89.4%) was self-help farmer, and in West Kalimantan the majority (73.26%) was PIR partnership farmer. The criterion for this study that oil palm is under the condition of a yielding plant (TM).

A. Technology Adoption Intensity

The technology adoption intensity is calculated by using the following formula:

$$\text{Adoption Intensity} = \left[\frac{n}{N}\right] \text{x } 100\ \%$$

Where n is the number of farmers who adopt technology and N is the number of farmers. The intensity of adoption represents the percentage of farmers who have adopted oil palm technology in this study.

B. Poisson Regression Model

To find out the factors that influence the adoption of technology on smallholder oil palm in Riau is using the Poisson regression method. The Poisson model is used to assess the factors that influence the adoption of smallholder oil palm technology. Poisson regression is included in GLM and is a form of regression analysis used for the data calculation model (Cameron et al. 1998). In modeling Poisson regression, log mapping is used as follows:

$$g(\mu_i) = \ln\mu_i = x_i'\beta$$

To estimate parameters in Poisson regression is using *Maximum* Likelihood *Estimation* (MLE).

III. Results

A. Characteristics of Respondents

The age of smallholder oil palm farmers in Riau ranges from 18-98 years and in West Kalimantan ranges from 18-86 years. In general, the average age of farmers is around 46 years. The majority of respondents both in Riau and in West Kalimantan from smallholders aged between 40-59 years, which were 56.19% and 56.04% respectively. This implies that smallholder oil palm farmers in Riau province and West Kalimantan were dominated by middle-aged producers who are productive and provide income to meet basic family needs. When viewed based on the management pattern, it can be seen that farmers in PIR partnerships and self-help smallholders do not differ greatly. Farmers in the PIR partnership pattern with average of 46.12 years and self-help pattern farmers with average of 45.67 years.

The majority (39.74% and 43.77%) of oil palm producers in Riau and West Kalimantan only graduated from elementary school. Furthermore, around 16.29% and 20.7% did not have formal education/did not complete elementary school. This implies that the majority of farmers have reached the level of basic education with an average farmer education of around 7.39 years (equivalent to 7th-grade junior high school). From the data obtained only 1.54% of oil palm farmers are people who have studied undergraduate level. Distribution of education levels based on management patterns, the education level of independent smallholders is higher than the level of education of PIR partnership farmers. The education level of PIR partnership farmers was more dominated at the Elementary School (SD) level and who did not complete primary school at 64.68%. However, self-help

smallholders were dominated by the level of elementary and junior high schools (SMP) of 64.42%.

It is interesting to see from the data that the majority (80.42%) of smallholder oil palm farmers in Riau were not members of farmer groups. This shows that membership in farmer groups in Riau has not played an important role, especially in self-help patterns. This implies that smallholder farmers in Riau do not yet have a strong community of oil palm farmer organization. In contrast, in West Kalimantan the majority of farmers are members of farmer groups (54.6%). This fact is due to the fact that most of the oil palm farmers in Riau are mostly self-help farmers, and in West Kalimantan most of the farmers were PIR partnerships. When viewed based on the management pattern, the majority (73.47%) of farmers in the PIR partnership pattern were members of farmer groups. From the questionnaire data on farmers who are not members of farmer groups, information was obtained that the biggest reason why smallholder oil palm farmers were not included in farmer groups is the absence of oil palm plantation farmer groups in their area (63.99%). Other reasons were the location of farmer groups (4.91%), farmers' disappointment because the farmer's group activities were not as expected (5.46%), unsatisfactory services (10.81%) and others (14.83%).

In line with the membership data of farmer groups, the majority (85.54%) of smallholder oil palm farmers in Riau were also not members of the KUD. In contrast, in West Kalimantan the majority of farmers were KUD members (70.88%). This phenomenon is due to the fact that farmers in the PIR partnership pattern in West Kalimantan were more dominant than self-help farmers. Whereas in Riau the dominant pattern was self-help farmers. Distribution of percentage of farmer membership in KUD based on management patterns. Generally, farmers in the PIR partnership pattern were KUD members (81.43%) and vice versa in self-help smallholders were generally not KUD members (90.69%).

B. Characteristics of Smallholder Oil Palm Cultivation

Most of the smallholder oil palm land in Riau and West Kalimantan ranges from 0-2 hectares (82.40% and 73.63%) or qualify as small farmers. The rest are middle farmers. In this study, large farmers (land area> 15 hectares) were excluded, because they were relatively very few and quite difficult in data processing (an outlier effect). The average area of smallholder oil palm farmers in Riau was lower compared to West Kalimantan, with an average area of 1.80 hectares and 2.36 hectares. Generally, farmers, both in the PIR partnership pattern and self-help pattern only had a land area of between 0-2 hectares (78.11% and 81.22%). The average area of farmers in the PIR partnership pattern was 2.29 hectares, which is slightly wider than the self-help farmers, which was only 1.93 hectares.

The majority, almost half of plants in Riau were (47.99%) young plants (aged 3-8 years) with an average age of 10.62 years and with a plant age range of 3-33 years. Whereas in West Kalimantan, the majority (58.06%) were mature plants (aged 14-20 years) with an average age of 17.21 years and a plant life span of 4-34 years.

Interestingly, the majority (75.72%) of farmers in Riau did not use certified seeds and on the contrary in West Kalimantan mostly used certified seeds (94.14%). This indicates that farmers' awareness of the use of certified seeds in West Kalimantan is better than in Riau. This is because the composition of the pattern of management of smallholder oil palm plantations in West Kalimantan is dominated by the PIR partnership pattern compared to that in Riau which is dominated by self-help pattern. Most (92.54%) farmers in the PIR partnership pattern used certified seedlings, while self-help farmers used certified seeds that were relatively low (22.66%). This indicates that farmers in the PIR partnership pattern are more required to use superior seeds by partner companies, compared to self-help farmers.

Based on the standard dose of PPKS, it can be seen that the use of urea fertilizer in West Kalimantan is closer to the standard dose compared to farmers in Riau. But in general, the smallholder oil palm farmers in Riau and West Kalimantan were still below the recommended dosage given by PPKS (Figure 1a). The average use of urea fertilizer in farmers in Riau was 1.17 kg / tree, lower than farmers in West Kalimantan, which was only 2.28 kg / tree. The average use of urea fertilizer for farmers in the PIR partnership pattern was 2.21 kg / tree, far better than self-help smallholders, which was only 1.25 kg / tree (Figure 1b). From this, it can be seen that the partnership farmers have approached the standard PPKS dose of 2.81 kg / tree.

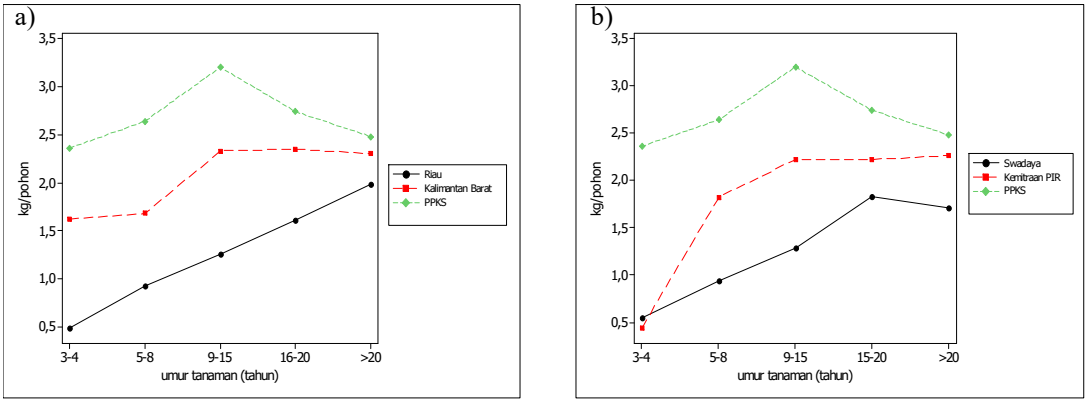

Figure 1. Use of Urea Fertilizer

The use of SP36 fertilizer in West Kalimantan was closer to the standard dose compared to farmers in Riau. However, in general, fertilizer used by smallholder oil palm farmers were still below the recommended dosage given by PPKS (Figure 2a). The use of SP36 fertilizer in Riau averages was only 0.81 kg/tree, while in West Kalimantan an average of 1.58 kg/tree has approached the standard dosage of PPKS. If viewed from the use of SP36 fertilizer based on management patterns, it can be seen that farmer in the PIR partnership pattern was better, compared to self-help farmer (Figure 2b).

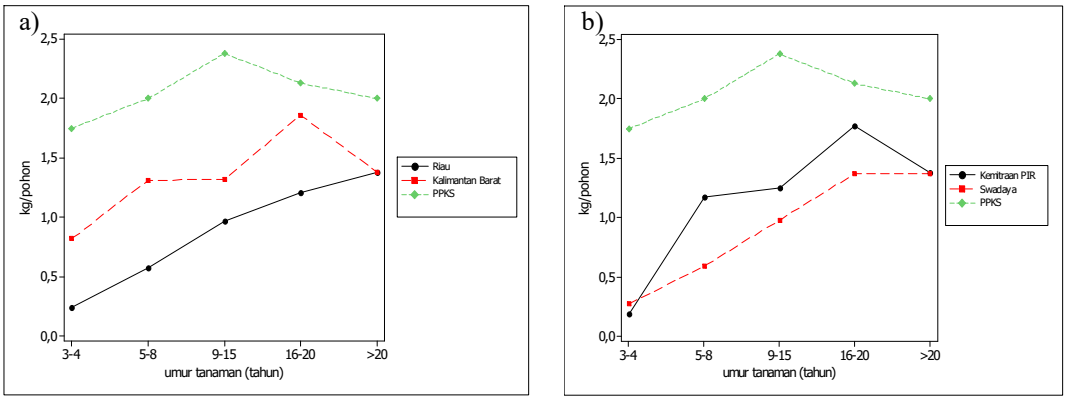

Figure 2. Use of SP36 Fertilizer

Based on the standard dose of PPKS, it can be seen that in general the use of MOP fertilizers in Riau and West Kalimantan was still far from the recommended dosage standard, but farmers in West Kalimantan were slightly better than farmers in Riau (Figure 3a). The use of MOP fertilizers in Riau was only 0.83 kg/tree, while in West Kalimantan it was slightly better of 1.07 kg/tree. While the standard dosage of PPKS was 2.40 kg/tree. If viewed from the use of MOP fertilizers based on management patterns, it can be seen that farmers in the PIR partnership pattern were slightly better, when compared to self-help farmers. (Figure 3b). The average use of MOP fertilizer by farmers in the PIR partnership pattern was 1.26 kg/tree, whereas for self-help farmers it was only 0.75 kg/tree.

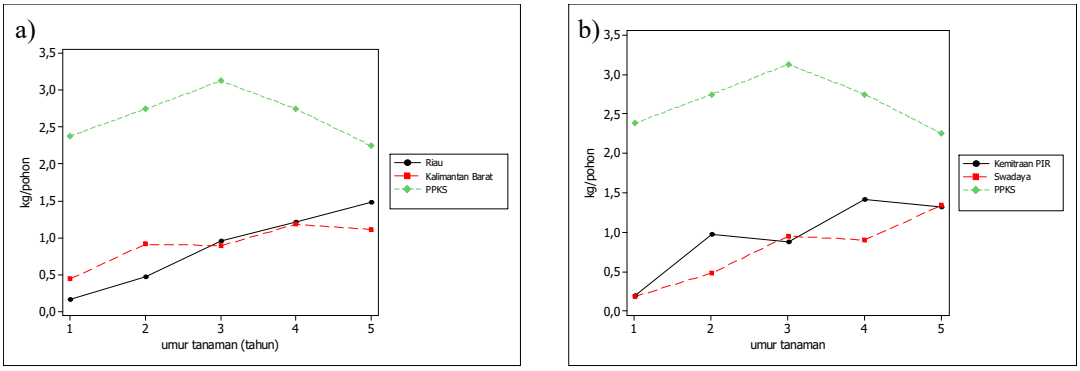

Figure 3. Use of MOP fertilizer

The use of dolomite fertilizer in Riau was only 0.10 kg/tree, while in West Kalimantan it was only 0.05 kg/tree, while the recommended dosage from PPKS was 2.05 kg/tree. This implies that in general, the use of dolomite fertilizers in smallholder oil palm farmers was still very low (Figure 4a).

Likewise, when reviewed from the management pattern, the use of MOP fertilizer was still very low (Figure 4b). It can be seen that the average use of MOP fertilizer by farmers in the PIR partnership pattern was 0.09 kg/tree, whereas for self-help farmers it was only 0.08 kg/tree.

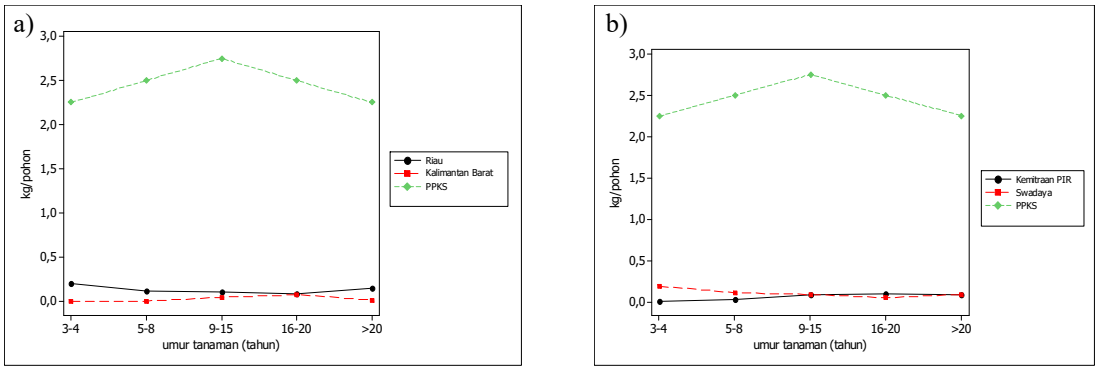

Figure 4. Use of Dolomite Fertilizer

The amount of pesticides used by farmers in maintaining palm oil in this study was in Riau (3.49 liters/hectare) and in West Kalimantan (3.86 liters/hectare). In Riau, the biggest use of pesticides (43.1%) was at 5-8 years of plant age, while in West Kalimantan the biggest use of pesticides (47.3%) was at 16-20 years of plant age. When viewed from the management pattern, it can be seen that the PIR partnership pattern had slightly more use of pesticides which was around 3.76 liters/hectare, while for self-help farmers around 3.51 liters/hectare. In partnership pattern farmers, the use of pesticides was greatest (40.6%) when plants aged 16-20 years, while in self-help farmers, the biggest use of pesticides (45.3%) was at 5-8 years of plant age.

The average production of farmers in West Kalimantan (14.63 tons of FFB/hectare) with an average land size of 2.36 hectares was slightly higher compared to farmers in Riau (13.39 tons of FFB/hectare) with an average land size of 1.80 hectares. If it is reviewed based on the management pattern that farmers with PIR partnership pattern (16.15 tons of FFB/hectare) had an average land size of 2.29 hectares, which means the productivity is higher compared to self-help farmers (12.86 tons of FFB/hectare) with an average land size of around 1.81 hectares. However, when compared to the ideal production potential (27 tons of FFB/ha) is still relatively low. Thus, there is still an opportunity to increase productivity by 40.70% for PIR partnership pattern farmers and 49.74% for self-help pattern farmers if cultivated intensively.

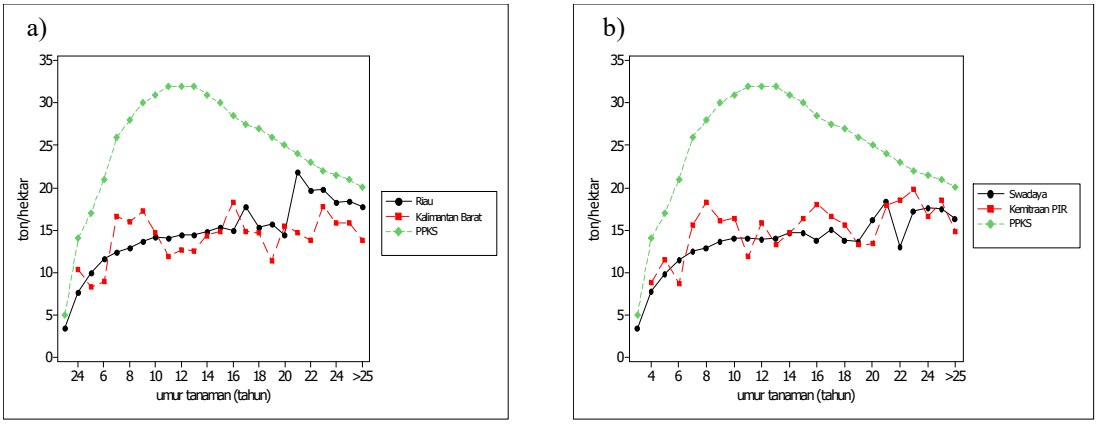

Figure 5 Graph of Smallholder Oil Palm Average Productivity

C. Intensity of Oil Palm Technology Adoption

Based on the Regulation of the Indonesian Ministry of Agriculture No: 131/Permentan/OT.140/12/2013 concerning the Guidelines for Cultivating Good Oil Palm (Elaeis guineensis), the technology of oil palm cultivation which is important to observe in this research are: certified seeds, fertilization (urea, SP36, MOP, and dolomite), how to plant, pest control (OPT), and maintenance. The amount of oil palm technology adopted by farmers ranges from 0 to 8. The average level of intensity of technology adoption for smallholder oil palm farmers in Riau was 4.55 and for farmers in West Kalimantan was 5.81. While in combination (Riau and West Kalimantan), the average intensity level of technology adoption was 4.83. Approximately 0.8% of smallholder oil palm farmers in Riau did not adopt technology. The majority (37.8%) of smallholder oil palm farmers in Riau adopted 4-5 technologies. While the majority of oil palm farmers in West Kalimantan (70.9%) had adopted 6-8 technologies.

Table 1 The intensity of technology adoption and oil palm production in Riau and West Kalimantan.

Number of technologies applied	Riau			West Kalimantan			Combination		
	Number of Adopter	%	Production (ton/ha)	Number of Adopter	%	Production (ton/ha)	Number of Adopter	%	Production (ton/ha)
0	16	0.8	6.46	0	0.0	.	16	0.7	6.46
1	75	3.9	9.62	5	0.9	7.58	80	3.3	9.49
2	209	10.9	10.54	9	1.6	5.65	218	8.9	10.34
3	209	10.9	10.86	22	4.0	12.08	231	9.4	10.97
4	312	16.3	12.87	66	12.1	11.32	378	15.4	12.60
5	411	21.5	13.93	63	11.5	15.85	474	19.3	14.19
6	496	25.9	14.72	167	30.6	16.01	663	26.9	15.04
7	176	9.2	17.72	208	38.1	15.09	384	15.6	16.30
8	11	0.6	17.30	6	1.1	12.23	17	0.7	15.51
Total	1915	100.0	13.39	546	100.0	14.63	2461	100.0	13.67

Source : Plantation household survey BPS, 2014 (processed)

The average level of intensity of technology adoption for self-help farmers was 4.48 and for partnership farmers was 5.91. While in combination, the average level of intensity of technology adoption was 4.83. About 0.9 percent of self-help farmers did not adopt technology at all. The majority (39%) of self-help farmers adopted 4-5 technologies. Whereas the majority of farmers in the partnership (74.1%) had adopted 6-

8 technologies and were more productive than self-help farmers.

Table 2 The intensity of technology adoption and oil palm production based on management type in Riau and West Kalimantan..

Number of Technologies Applied	PIR Partenrship			Self-Help			Combination		
	Number of Adopter	%	Production (ton/ha)	Number of Adopter	%	Production (ton/ha)	Number of Adopter	%	Production (ton/ha)
0	0	0.0	.	16	0.9	6.46	16	0.7	6.46
1	1	0.2	19.62	79	4.3	9.37	80	3.3	9.49
2	9	1.5	6.36	209	11.2	10.51	218	8.9	10.34
3	23	3.8	13.28	208	11.2	10.72	231	9.4	10.97
4	60	10.0	12.70	318	17.1	12.58	378	15.4	12.60
5	69	11.4	16.39	405	21.8	13.81	474	19.3	14.19
6	208	34.5	17.79	455	24.5	13.79	663	26.9	15.04
7	223	37.0	16.22	161	8.7	16.41	384	15.6	16.30
8	10	1.7	14.72	7	0.4	16.65	17	0.7	15.51
Total	603	100.0	16.15	1858	100.0	12.86	2461	100.0	13.67

Source : Plantation household survey BPS, 2014 (processed)

Table 3 presents the estimation of the Poisson regression model for smallholder oil palm farmers in Riau. From this model shows that the income of farmers and farmer group members was the main factor that significantly influenced the intensity of technology adoption (1% real level). Farmer income had a positive influence on the intensity of technology adoption by farmers, and membership of farmer groups had a positive and significant influence on the intensity of adoption. This implies that farmer institutions will help farmers to adopt better oil palm technology.

Table 3 Poisson model for factors that influence the intensity of technology adoption in smallholder oil palm farmers in Riau

Variable	Coefficient	Robust Std. Error	Wald Chi-Square	Sig.
Constant	3.306	0.2142	238.158	0.000
Self-help pattern	-0.030	0.0737	0.168	0.682
Family support	-0.001	0.0197	0.003	0.957
Gender	0.061	0.0978	0.392	0.531
Age	-0.003	0.0026	0.894	0.344
Education	0.012	0.0084	1.977	0.160
Plant age	0.009	0.0061	2.282	0.131
Farmers' income	2.114E-5***	4.7699E-6	19.637	0.000
Farmers group	0.494***	0.0905	29.788	0.000
KUD	0.094	0.0638	2.188	0.139
Number of Observation	1915			
Likelihood ratio Chi2	966.008			
Log Likelihood	-1824.588			*** shows 1 % significant

Source : Plantation household survey BPS, 2014 (processed)

Table 4 Poisson model for factors that influence the intensity of technology adoption in smallholder oil palm farmers in West Kalimantan

Variable	Coefficient	Robust Std. Error	Wald Chi-Square	Sig.
Constant	4.507	0.2302	383.405	0.000
Self-help pattern	-0.415**	0.1910	4.725	0.030
Age	0.003	0.0021	1.611	0.204
Education	0.017	0.0110	2.290	0.130
Family Dependent	-0.019	0.0315	0.372	0.542
Plant age	-0.018***	0.0061	8.733	0.003
Number of Observation	546			
Likelihood ratio Chi2	31.418			** shows 5 % significant
Log Likelihood	-137.861			*** shows 1 % significant

Source : Plantation household survey BPS, 2014 (processed)

Table 4 presents the estimation for smallholder oil palm farmers in West Kalimantan. From this model shows that self-help patterns and plant age are the main factors that significantly influence the intensity of technology adoption (5% and 1% significant levels). The self-help farmer had a negative effect on the intensity of technology adoption, so that self-help farmer pattern did not have an influence on increasing adoption of technology. While the age of plants had a negative influence on increasing the intensity of technology, which means that the younger the age of the plant, the smallholder oil palm farmers in West Kalimantan tend to get better technology applied.

Table 5 Poisson model for factors that influence the intensity of technology adoption on self-help oil palm farmers in Riau and West Kalimantan

Variable	Coeffcieint	Robust Std. Error	Wald Chi-Square	Sig.
Constants	3.206	0.2219	208.642	0.000
Location in West Kalimantan	0.540***	0.1961	7.597	0.006
Family Dependent	-0.001	0.0210	0.004	0.948
Gender	0.050	0.0924	0.296	0.586
Age	-0.001	0.0031	0.180	0.672
Education	0.016*	0.0091	3.029	0.082
Plant age	0.008	0.0069	1.472	0.225
Farmers' income	2.171E-5***	5.0916E-6	18.186	0.000
KUD	0.536***	0.1079	24.693	0.000
Farmers group	0.066	0.0723	0.820	0.365
Number of Observation	1858			
Likelihood ratio Chi2	705.917			* shows 10 % significant
Log Likelihood	-1804.661			*** shows 1 % significant

Source : Plantation household survey BPS, 2014 (processed)

Table 5 presents the estimation of the Poisson regression model for smallholder oil palm farmers on self-help pattern. From this model shows that the location of farmers in West Kalimantan, farmer education, farmer income, and KUD membership were the main factors that significantly influenced the intensity of technology adoption (significant with a significant level of 10% and 1%). The location of farmers in West Kalimantan had a positive influence on the intensity of technology adoption. From the analysis of the results of analysis that farmers in West Kalimantan were more responsive to the applied technology than farmers in Riau. This is because the majority of oil palm farmers in West Kalimantan (73.26%) are partnership farmers. Guidance from farmer partners is the reason why farmers are more responsive to technology. Farmer income had a positive influence on the intensity of technology adoption, this implies that with the better income of farmers, farmers can be better in their efforts to maintain their gardens in accordance with standard recommendations. The results of the analysis show that KUD membership had a positive and significant influence on the intensity of adoption. This implies that farmer institutions will help farmers to adopt better oil palm technology. And finally, farmer education had a positive influence on increasing the intensity of technology, which means that formal farmer education can better influence the implementation of oil palm cultivation technology.

Table 6 presents the estimation of the Poisson regression model for smallholder oil palm farmers in the PIR partnership pattern. From this model, it shows that only the location of farmers in Riau was the main factor that significantly influenced the intensity of technology adoption (significant with 5% significance level). The location of farmers in Riau had a negative effect on the intensity of technology adoption. From results of analysis, farmers in Riau were less responsive to applied technology than farmers in West Kalimantan. This is because the majority of oil palm farmers in West Kalimantan (73.26%) are partnership farmers.

Table 6 Poisson model for factors that influence the intensity of technology adoption on PIR partnership oil palm farmers in Riau and West Kalimantan

Variable	Coefficient	Robust Std. Error	Wald Chi-Square	Sig.
Constants	4.392	0.2982	216.860	0.000
Location in Riau**	-0.169	0.0872	3.777	0.052
Family Dependent	-0.016	0.0296	0.303	0.582
Gender	0.034	0.0457	0.545	0.460
Age	0.002	0.0026	0.334	0.563
Education	0.005	0.0144	0.137	0.711
Plant age	-0.013	0.0090	2.239	0.135
Farmers' income	3.298E-6	4.1134E-6	0.643	0.423
Counseling	0.129	0.1034	1.564	0.211
Farmers group	0.120	0.0743	2.600	0.107
Jumlah observation	603			
Likelihood ratio Chi2	25.676			
Log Likelihood	-189.475			** shows 5 % significant

Source : Plantation household survey BPS, 2014 (processed)

IV. Conclusion And Suggestion

A. Conclusion

This study concluded that for smallholder oil palm farmers who increase the intensity of technology adoption, their productivity increases. Therefore, because farmers adopt all palm oil technologies, they are more productive than farmers who do not adopt or adopt partially from the recommended technology.

In Riau, the management pattern, KUD members, farmer group members, assistance program and farmers' income were factors that significantly influenced the intensity of technology adoption. KUD membership, farmer group membership and assistance were positive and significant. In West Kalimantan the factors that significantly influenced the intensity of technology adoption were assistance and farmers group membership.

B. Suggestion

1. Oil palm productivity increases with the increasing number of technologies adopted; which shows that cultivation with improved technology will shift the production limit to the top. Therefore, it is recommended that smallholder oil palm farmers, both PIR partnership and self-help, be able to adopt technology and best practices on their farms to increase their productivity.
2. This research revealed that farm institutional access had a positive influence on the intensity of adoption and productivity. It is necessary to strengthen the smallholder oil palm farmers' institutions
3. Farmers are advised to increase the technical knowledge of oil palm cultivation and management by participating in counseling. Extension services from government, private sector and NGOs need to be strengthened by increasing the intensity of counseling with oil palm farmers.

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