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The Effect of Oil Palm Expansion on Farmers' Household Food Security in Indonesia

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Abstract
This study captures the ex post impact analysis of oil palm expansion on food security at the micro level in Indonesia. The main focus is to examine the effect of oil palm expansion on farm households' food security situation, including food expenditure as well as daily calorie and nutrient intake. OLS and quantile regression models are applied to find the socioeconomic factors that influence farmers' food expenditure and calorie intake, and to examine whether the effect of oil palm expansion on food security differs across quantiles. The findings highlighted significant influence of the income from oil palm expansion to calorie intake. Increases on farmers expanding farmland could lead farmers to consume more calories nutritious food, but the food budget on food decreases. However, the result pronouns income earning from oil palm plays a significant role in ensuring food security. As the first paper on providing the ex-post analysis of oil palm expansion, it is expected to show the distribution of food security impact across households' income level in Indonesia. Previous studies on livelihood analysis of oil palm cultivation mostly focus on comparing the oil palm grower with other crops. Hence, it may lead to undirected implication on how to enhance the future oil palm expansion program. The result of this study is offered to support policy implication on the design of future oil palm expansion program by the Government of the Republic of Indonesia.
Keywords: oil palm expansion, farm household, food security, quantile regression

1. Introduction

As the main source of biofuel and the product for consumption by human, livestock, as well as pharmaceutical industry, oil palm has boomed dramatically and its crop area almost tripled over the last two decades (FAO, 2014). Moreover, the Indonesian government support has been provided which focuses on developing oil palm plantations, particularly for smallholders in order to create job opportunities and reduce poverty in rural areas (Sheil *et al.,* 2009). The oil palm area expansion and production have significant impacts in increasing farmers' income and consumption expenditure (Alwarritzi *et al.,* 2015). Furthermore, it is important to understand the government strategies that affect smallholder farmer production, so that they can earn better income. The crucial aspect to be analyzed for recent oil palm expansion is the farmers' access to sufficient, safe, and nutritious food as their basic need, popularly known as food security.

Oil palm expansion in Indonesia is quite a challenging program, which is expected to eradicate hunger, considering that there is a widespread malnutrition among children, and about 11.4% of the population lives below the poverty line (FAO, 2014). Since oil palm is a non-food cash crop, the impact of oil palm expansion to farmers' food security is uncertain. Similar to the situation in India, where genetically modified (GM) cotton is promoted by the government to induce rural income, oil palm has been seen as a pathway to influence the farmers' socioeconomic condition, particularly in improving or worsening farmers access to food (Qaim & Kouser, 2013).

The ex post effect of oil palm expansion is a widely debated topic (Baker, 2010; Alwarritzi *et al*., 2016; Krishna *et al.,* 2015), but there are few studies that focuses on its impact on farmers' food security. The heterogeneous effects of oil palm expansion on food expenditure and calorie intake might be pronounced because the income elasticity of oil palm farmers' demand is different. Oil palm farmers with large farm area may have positive effect on calorie consumption, but the opposite is true for food expenditures. The expansion might positively affect nutritious food intake, particularly at the mid to upper tail of total expenditure distribution, implying that households in this category spend their income to not only fulfil their basic calorie needs, but also consider the nutrient intake quality in their daily diets (Euler, 2015). However, Previous studies on livelihood analysis of oil palm cultivation mostly focus on comparing the oil palm grower with other crops (rubber plantation). Hence, it may lead to undirected implication on how to enhance the future oil palm expansion program. Investigation of the oil palm expansion impact on food security among farmers with different income distribution and farm size expansion is important in order to highlight in which level farmers household may received significant impact.

The present study analyzes the impact of oil palm expansion on farm household food intake in Indonesia, including food expenditure, calorie intake, and dietary quality. As the first study to examine the impact of oil palm expansion on food security using micro-level data, we carried out a comprehensive household survey in 2015. We focus on the analysis by referring to the definition of food security by the FAO: "a situation

that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preference for an active and healthy life." This definition consists of four key components of food supply: availability, stability, accessibility, and utilization. A food system is vulnerable when one or more of these four components are uncertain or insecure (FAO, 2008).

2. Data and Methods

A total of 271 sample households from four major villages in Riau were purposefully selected to represent the characteristics of the plantation scheme. Two villages (Mekar Jaya and Makmur) are under Nucleus Estate Smallholders (NES) schemes or transmigration villages that were established in the 1990s, while the other two villages independently cultivate oil palm. Within each village, we selected farm households depending on whether they had experienced oil palm farmland expansion vis-à-vis their farm size exceeding two-hectare area over two decades. Then, the farmers as "expansion farmer" if they had expanded oil palm farm size and "non-expansion farmer" if otherwise were termed (Alwarritzi *et al*., 2016). A structured questionnaire was designed to gather detailed information regarding various agricultural and socioeconomic information, including input-output of oil palm production, household characteristics, income sources, and technical assistance related to food security. Furthermore, the survey on annual household expenditure on food consumption was conducted to obtain information on farmers' per capita expenditure and their consumption behavior.

In a survey questionnaire with a 7-day recall period covering 12 food group items, households were asked about the quantity of different food items consumed and their corresponding monetary value. Food consumed by farm households included market purchases, home production, and meals taken or given from outside home. Meals taken or given from outside were converted using average market prices as paid by other households living in the same village.

The current study covers the energy content and nutritional composition of all food items that were converted from national food composition tables as developed by the Sustainable Micronutrient Intervention to Control Deficiencies and Improve Nutritional Status and General Health in Asia, known as SMILING project (2013). The total consumption of calories from highly nutritious food included seafood, animal products, fruits, and vegetables. The daily household calorie consumption was divided by the number of adult equivalent (AE) in a household to obtain the calories consumed per AE per day using AE conversion factors for estimated calorie requirements according to age and gender (Claro *et. al.,* 2010).

The OLS model was specified to investigate the impact of oil palm expansion and other socioeconomic factors on food expenditure and calorie intake, which is as follows:

$$Y_i = \alpha + \gamma EP_i + \sum_{h=1}^{H} \beta_h X_i + \rho V_i + \varepsilon_i \quad (1)$$

where the dependent variable Y for ith household includes annual expenditure for food, daily calorie consumption, and calorie from nutritious food. The dummy variable indicating whether farmers expand their oil palm farm size during two decades (from 1990s until the survey period) is specified as EP_i where vector γ provides the conditional mean effect of EP_i. The socioeconomic factors in vector X_i contain household head's age, years of education, number of family members, total annual income, and some dummy variables. Since farmers are categorized as NES scheme and independently reside in different villages. Then V_i is specified as dummy variable of village, either under the transmigration scheme or non-transmigration village. Furthermore, γ, β_h and ρ are the parameter vectors to be estimated, and ε_i is the random error term with zero mean and constant variance. The analysis on the effect of oil palm expansion on food expenditure and calorie consumption might lead to heterogeneity among expansion and non-expansion farmers due to different motivation and socioeconomic background. The alternative solution for investigating the effect under heterogeneous effect is to apply quantile regression specification (2), which is introduced by Koenker and Bassett (1978) as the median regression generalization to other quantiles. The quantile regression allows estimating the effect in the condition that changes the conditional distribution of the dependent variable (Roger & Hallock, 2011). Previous studies have applied the quantile regression to model the heterogeneous effect from wheat price (D'Souza & Jolliffe, 2012), oil palm adoption (Euler, 2015), and farming technology adoption (Sanglestwai *et al*., 2014). The conditional quantile regression of Y_i for any given value of xi can be expressed as

$$Q_\tau(y_i|x_i) = X_i\beta_\tau \quad (2)$$

where $Q_\tau(y_i|x_i)$ is the conditional quantile function at τ quantile with $0 < \tau < 1$, and β_τ is the respective unknown parameter vector that can be estimated at any point of conditional distribution of dependent variable by asymmetrical weighing of absolute residual values. This study estimates three different quantile levels of the conditional distribution of respective dependent variable (τ= 0.25, 0.50, 0.75). We apply the same vectors of household socioeconomic and farm attributes as in the OLS regression analysis.

Table 1 presents the summary statistics of dependent and independent variables used in this study. The dependent variables cover the ability of households to achieve food security on their access to and control over certain "assets" or "capitals," which may be categorized as human capital, financial capital, natural capital, and social capital (WFP, 2009). The independent variables represent households' annual budget on food, daily

calorie intake, and daily intake from nutritious food. The explanatory variables are related to households' farm assets and demographics including dummy for whether farmers expand oil palm farm size, annual income from oil palm, household head's age, years of education, number of family members, dummy for whether household have other farm income, and access to agricultural credit. Furthermore, several social capital and market access variables are considered, including dummy variables for contact with food program extension services and the contract farming system. The model is also controlled for diverse village attributes that vary among the four sample villages by incorporating a regional dummy variable of independent village where transmigration village is a reference.

3. Results and Discussion

3.1 Characteristics of Oil Palm Farmers

Table 2 shows the descriptive analysis of dependent and independent variables. The average expanded farm household spends significantly higher on annual food than the non-expansion household does. Generally, the daily calorie consumption for both groups is higher compared to the national average, which was around 1,900 kcal per capita in 2012 (BPS, 2015). As for the daily food intake, expansion farmers consume more calorie than the non-expansion farmers, and the expansion farmers consume nutritious food more than the non-expansion farmers. This implies that the expansion farm household might need higher energy for operating oil palm farmland, which is larger than that of the non-expansion farmers. Furthermore, the expansion group not only increases their daily calorie consumption, but also improves the diet quality by adding more nutritious and assorted foods.

The oil palm farm size was found significantly different between both groups. In our sample, from 271 total respondents, around 74% of the farmers expanded their oil palm farmland from small scale to medium and large scale (more than three hectares) during 1990 to 2014. On average, the expansion farmers grow oil palm under six hectares of farmland, implying that farmers have the ability to operate medium scale even though most of them are smallholders and conventional farmers. Both groups have significant difference in income levels, suggesting that besides having higher production, the wider cultivation area drives economies of scale and could lead to operating cost efficiency (Alwarritzi *et al.,* 2015). The study reveals that oil palm farmers are in the less productive life phase with an average age of 51 years. In both groups, farmers generally have at least nine years of educational experience or similar secondary education, implying that oil palm farmers are running plantations without adequate farming-related background. Based on field observation, most farmers learned farming practices from experience, enhanced by knowledge sharing among farmers. Regarding the number of family members in adult equivalent, the data show insignificant difference between expansion and non-expansion farm households.

3.2 The Impact Of Oil Palm Expansion And Socioeconomic Factors On Food Security

Since the Indonesian government supports oil palm expansion by facilitating farmers' access to bank loans, the average values for the credit use variables differ significantly between groups. Farm households engaged in the extension class for the food self-sufficiency program is insignificantly different between the two groups, implying that this program was well disseminated and had attracted farm households in the study area. Thus, farm households might gain more knowledge about the know-how to enhance their dietary quality as well as maintain their available land to produce nutritious food such as vegetables and fruits. Lastly, we found that higher percentages of non-expansion farm households are residing in non-transmigration villages rather than in transmigration villages. This implies that oil palm expansion is closely related to the knowledge transfer among neighboring farmers, and the NES trans scheme is a good example, as they have good farmers' associations (Alwarritzi *et al.,* 2015).

As explained in the previous section, the OLS applied model to further analyze the impact of oil palm expansion on food security among oil palm farm households in the study site (see Table 2). The result reveals that the increasing percentage of farmers expanding farmlands might lead households to consume more daily calorie and nutritious food, implying that a larger oil palm cultivation area requires more productive labor to operate farming activities. Similarly, previous study has shown that oil palm farm households consume more calories from daily consumption of nutritious food (Euler, 2015). However, the budget on food decreased by IDR0.89 million as the farmers tend to expand oil palm farmland, which is consistent with Engel's law, suggesting that larger oil palm area leads to lower proportion of household income being spent on food. The tendency for decreased amount of food budget was found among non-food cash crops in India as well (Qaim & Kouser, 2013).

Interestingly, the result suggests that the effect of an increase income significantly enhances the total annual food expenditure, daily calorie intake, and nutritious food consumption by around IDR12,000, 1.05 kcal/AE, and 3.48 kcal/AE, respectively. Previous studies have shown that income significantly influences food expenditure mainly through labor productivity (Rist *et al.,* 2010), and increases healthy food diversity index

(Larissa *et al*., 2009); however, it has relatively small or negative impact on daily calorie intake and dietary quality among low income households (Doan, 2014).

Furthermore, other socioeconomic factors also influence food expenditure and calorie intake of oil palm farm households. Farmers' years of education are positively associated with daily calorie intake and nutritious food consumption (increased by 6.04 and 6.68 kcal/AE, respectively), suggesting that better education might be correlated with farm income through better agronomic management practice. The coefficient of household size (AE) is negative and significantly different from zero for food expenditure, implying that the food budget decline with the increasing household size. This is probably because a larger household has a higher number of children who eat less than adults (Abdullai & Aubert, 2004).

The Indonesian government to improve food self-sufficiency in rural areas established the service for food security program. Based on this result, the household dummy variable, particularly the housewife joining this program, significantly increases the daily food expenditure and calorie intake (by IDR0.68 million and 86.78 kcal/AE, respectively). The Indonesian government expects that by joining this program, farm households might strengthen the sustainability of their food security through extension service staff providing knowledge on food diversity and optimization of land use, including nursery group progression and nutritious food processing (KEMENTAN, 2014). Previous study by Diansari and Nanseki (2015) suggested that counseling and community assistance programs are essential to upgrade household members' food nutrition knowledge, preferably in small groups to ensure that the program message is effectively delivered.

Lastly, there is a significant effect of village variation, implying those farm households living in non-transmigration village negatively affect their budget on food and calorie intake. This is probably due to relatively lower farming performance compared to transmigration village (Alwarritzi *et al*., 2015), which might lead to lower income earning and purchasing power, particularly on food.

3.3 Distribution of the Effect of Oil Palm Expansion on Food Security

Table 3 presents the results for the quantile regression. As explained in previous section, more comprehensive picture of the predictor variables' effect on the response variable can be obtained by using quantile regression. Quantile regression models the relation between a set of predictor variables and specific percentiles (or quantiles) of the response variable and allows comparing how some percentiles of farm household's food security indicator may be more affected by certain farmers' characteristics than other percentiles.

According to the OLS model, the average budget spent on food by a farm household that expanded its oil palm farmland is IDR890,000 lower than that of a farm household that had not expanded its oil palm farmland. The quantile regression results indicate that the effect of expanded farmland has a larger negative impact on the medium to higher quantiles of food expenditure. This lower food budget is probably because the expansion farm household spends much of their budget on non-food expenditure, particularly on the oil palm farmland, while food self-sufficiency exists as farmers produce food products from their available gardens. Koenker and Hallock (2001) highlighted the tendency of the food budget increase along with the household income increase as depicted in spacing of the quantile regression lines, which reveals that the conditional distribution of food expenditure is skewed to the left.

The calorie consumption effects of expansion farm household and income are positive and consistent across quantiles. This study suggests that positive income elasticity and land size may increase daily calorie and nutrition intake. Interestingly, some previous studies find that income enhancement may result in increases in total calorie intake, but this may not coincide with a diet richer in nutrients (Brinkman *et. al*., 2010; Skoufias, 2009). Within the scope of calorie intake, nutrition food has attracted considerable interest; numerous research studies have emphasized the importance of nutrition intake on health, such as vegetables, seafood, and other micronutrient food components. Low vegetable consumption is a major factor causing micronutrient deficiencies, and several widespread nutritional disorders including birth defects, weakened immune systems, mental and physical retardation, blindness, and even death are caused by diets lacking such micronutrients (FAO, 2003). Uusiku *et al*. (2010) review the nutrition and food consumption in sub-Saharan Africa, and emphasize the role of dietary fiber, particularly from vegetables, in the prevention of chronic and lifestyle diseases. By consuming adequate nutrients, it is expected that oil palm farm households might become more productive and continue with oil expansion program, as they will benefit their mental and physical health.

4. Conclusion and Implication

Recent study suggests that oil palm expansion enhances farm households' food security through better income and farmland expansion. Although oil palm is not a food cash crop, but the evidence implies that oil palm may be an important pathway to reduce the poverty problem such as hunger and malnutrition in Indonesia. However, note that the extent to which food expenditure and dietary quality change with increase in income will depend on the household consumption behavior as well as socioeconomic background. Thus, appropriate policy and regulatory frameworks are required to ensure to meet the farm households' needs to improve their food security

status.

The key findings of this study suggest several implications. First, policymakers will need to focus on the calorie intake change that results from the income earning and farm size expansion of the oil palm cultivation, so that lower income and non-expansion farm households do not decrease their daily calorie consumption and nutritious food intake. Since oil palm plantation is the major income source, it is necessary to improve farming production facilities and technologies so that farmers will become more productive. The other initiative is to facilitate farmers with direct marketing through contract farming system in order to ensure a fair price for their products and provide advisory support.

Second, since food expenditure is relatively higher in lower quantile group of farmers, this indicates that farmers with smaller farm size spend more of their income on food due to limited resources to meet their food needs, particularly to produce nutritious food products. Since only own small scale of land, non-expansion farmers do possess adequate land to cultivate home vegetables or raise livestock, and thus they have to allocate more budgets on food products. Educating farm households on food self-sufficiency might have a significant effect on disseminating required knowledge to produce their own nutritious food products and maintain dietary intake levels. Besides, this program can alleviate the negative effects of low formal education levels of most Indonesian farmers.

5. Future Research

The result has shown significant impact of income and expansion of oil palm farm size on food expenditure, calorie and nutrition intake. Further impact analysis using treatment effect models of oil palm expansion on food security will be our future research consideration.

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Table 1. Descriptive Statistic of Expansion and Non-expansion Farmers

Variable and unit	All (N=271)	Expansion (N=199)	Non-expansion (N=72)	Difference
Calorie expenditure and consumption				
Total annual food expenditure (Million IDR/AE)	5.20 (2.46)	5.21 (2.41)	4.16 (0.30)	1.05**
Daily calorie consumption (kcal/AE)	3033.14 (258.60)	3123.22 (201.91)	2784.18 (234.56)	339.04**
Daily calorie from nutritious food (kcal/AE)	1107.22 (301.40)	1207.28 (287.17)	830.67 (99.41)	376.61***
Farm and socio-economic characteristics				
Income from oil palm (Million IDR)	89.55 (62.46)	108.82 (61.73)	37.29 (20.34)	71.53***
Age of household head (years)	51.15 (7.44)	51.24 (6.61)	50.80 (9.36)	0.44
Education of household head (years)	9.09 (2.93)	9.17 (3.06)	8.87 (2.53)	0.3
Household size (number of AE)	4.23 (1.02)	4.20 (0.96)	4.54 (1.19)	-0.34
Having other farm income (dummy)	24 (0.43)	26 (0.44)	18 (0.39	8
Having credit (dummy)	75 (0.44)	88 (0.31)	35 (0.48)	53***
Extension for food program (dummy)	76 (0.43)	78 (0.42)	75 (0.43)	3
Contract farming (dummy)	85 (0.36)	99 (0.10)	45 (50)	54***
Village (dummy)	39 (0.49)	37 (0.48)	46 (0.51)	-9

Original field survey, 2014. Mean values are presented with standard deviation repectively. IDR is Indonesian Rupiah, 1 US$ = 13.000 IDR (Indonesian Rupiah). ***, **, * are significant at $P < 0.01$; $P < 0.05$; $P < 0.1$ respectively

Table 2. OLS Estimation Result for Rood Expenditure and Calorie Consumption.

Variable and unit	Total annual food expenditure (Million IDR/AE)	Daily calorie consumption (kcal/AE)	Daily calorie from nutritious food (kcal/AE)
Expansion (dummy)	-0.893***	225.895***	121.015***
	(-0.301)	(27.171)	(23.122)
Income from oil palm (Million IDR)	0.012***	1.054***	3.477182***
	(0.002)	(0.186)	(0.158)
Age of household head (years)	-0.008	-1.985	0.391
	(-0.014)	(1.282)	(1.091)
Education of household head (years)	0.021	6.039*	6.678**
	(-0.037)	(3.344)	(2.846)
Household size (number of AE)	-0.969***	-1.484	-4.463
	(-0.097)	(8.803)	(7.491)
Having other farm income (dummy)	0.284	-19.808	-16.892
	(0.238)	(21.456)	(18.259)
Having credit (dummy)	-0.311	-7.456	15.473
	(0.263)	(23.742)	(20.204)
Extension for food program (dummy)	0.679***	86.775***	20.482
	(-0.239)	(21.598)	(18.380)
Contract farming (dummy)	0.002**	55.836*	-30.967
	(0.346)	(31.251)	(26.594)
Village (dummy)	-1.942***	-209.529***	-107.9297***
	(0.251)	(22.707)	(19.324)
Constant	9.551***	2806.896***	767.3551***
	(1.019)	(91.952)	(78.252)
Observation Number	271	271	271
Adj. R-squared	0.59	0.69	0.83
F	37.60	56.7	134.76

Estimates Standard errors are shown in parenthesis. ***, **, * are significant at $P < 0.01$; $P < 0.05$; $P < 0.1$ respectively

Table 3. Quantile Regression Analysis Result

Variables and unit		Quantile Regression		
	OLS	**25th**	**50th**	**75th**
	Annual Food Expenditure (Million IDR/AE)			
	(N=271)	(N=91)	(N=90)	(N=90)
Expansion (dummy)	-0.89***	-0.88***	-1.14***	-0.93**
	(-0.301)	(-0.25)	(0.27)	(0.46)
Income (Million IDR/Year)	0.012***	0.01***	0.015***	0.016***
	(0.002)	(0.002)	(0.001)	(0.003)
Constant	9.55***	7.68***	8.24***	9.11***
	(1.019)	(0.94)	(-0.91)	(1.57)
	Daily calorie consumption (kcal/AE)			
	(N=271)	(N=93)	(N=88)	(N=90)
Expansion (dummy)	225.89***	66.28***	137.81***	207.39***
	(27.17)	(14.52)	(0.19)	(52.34)
Income (Million IDR/Year)	1.05***	1.105***	2.40***	3.43***
	(0.19)	(0.36)	(0.19)	(0.1)
Constant	2806.89***	2708.35***	2694.66***	2760.26***
	(91.95)	(177.12)	(97.19)	(49.17)
	Daily calorie from nutritious food (kcal/AE)			
	(N=271)	(N=91)	(N=90)	(N=90)
Expansion (dummy)	121.01***	8.53	11.34	34.35*
	(23.12)	(7.99)	(16.66)	(18.66)
Income (Million IDR/Year)	3.48***	4.21***	5.48***	6.12***
	(0.160)	(0.13)	(0.11)	(0.06)
Constant	767.36***	678.90***	621.59	610.18***
	(-78.25)	(63.14)	(56.36)	(27.07)

Estimates Standard errors are shown in parenthesis. ***, **, * are significant at $P < 0.01$; $P < 0.05$; $P < 0.1$ respectively