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Food Security of Farmer Households in The Papua Border Region In The Era of Industrial Revolution 4.0: Ordinal Logit Regression Model

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Abstract. This study aims to determine the factors that influence the food security of farmer households in the Papua border region. Twelve factors used in this study are maternal education, number of family members, price of rice, price of sweet potatoes, prices of cooking oil, prices of instant noodles, income, area of arable land, distance of buying food, share of food expenditure, reception of the rice for poor families (*raskin*), and farmer status (either local or transmigrant). This research uses primary data from direct interviews by asking a list of questions to farmer households in Jayapura City and Keerom District. The samples are randomly selected, and the total respondents are 160 farmer households, then the data analyzed by *Ordinal Logit Regression*. The results show that most of the household farmers classified as the food secure condition. Partially the number of family members, cultivated land area, the share of food expenditure and the price of sweet potato/cassava have a significant effect the probability of the occurrence of food security for farmer households significant at the 5% level of error, while dummy *raskin* significant at an error rate of 10%. The cultivated land area and dummy *raskin* have a positive effect on the food security of farmer households, while the number of family members, the price of sweet potato/cassava, and the share of food expenditure have a negative effect on farm household food security.Introduction

Food security is access by all people at any times to fulfill the need for food for an active, healthy life [1], and it is very dependent on agriculture since it is a source of food fulfillment. Agriculture is one sector in Indonesia's economic development, and one of the roles of agriculture is the provider of food. The presence of the industrial revolution affected this sector, from upstream to downstream. The Industrial Revolution 4.0 (4IR) is a new technological advancement that integrates the physical, digital, and biological world, where there is a fundamental change in the human's way of life [2]. The current industrial revolution has three major consequences in the agricultural sector. First, precise optimization will solve many current problems in agriculture. Agriculture is a representative industry in which inputs and outputs are inconsistent. In terms of worldwide food production, food should be sufficiently produced for the entire population. Second, the reversion of rural production elements, including human resources, will have a major impact on agriculture. Capital, labor, and technological resources that left farming villages in previous generations are likely to return during the 4IR. Third, 4IR technologies will have a significant impact on weather-related problems [3]. The use of technology that will enable

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increased agricultural production, especially food production will have an impact on people's food security. Therefore, Indonesians are trying to implement the 4IR.

In general, agricultural activities in border areas are still subsistence. The main actors in the agricultural sector are farmers who do not understand well the advanced farming techniques. The concept of agricultural development which is widely developed at this time is the concept of intelligent agriculture, which is also called smart farming or precision agriculture. This concept refers to the application of ICT (information communication technology) in agriculture. The main objective of the application of technology is to carry out optimization in the form of increasing yield (quality and quantity) and the efficiency of existing resources. If the yield increases, it will be able to meet the food needs of the population which is massively increasing [4].

Efforts to increase agricultural production could not separate from the application of mechanical, biological and chemical technologies [5]. Currently, transmigrant farmers are more common to use superior varieties and modern cultivation techniques, such as integrated pest management, plant maintenance techniques, fertilization, and use of agricultural machinery and tools [6]. They also have been utilizing support for agricultural physical infrastructures, such as irrigation facilities, farming roads, grain grinding machine, and other kinds of infrastructures.

The main actors in the agricultural sector activities in the border area are transmigrant and local farmers who did not understand the advanced farming techniques. Food crops and horticulture are still the main farming activities for farmers in this region. Farming patterns in the border region are divided into gathering, shifting cultivation, traditional sedentary farming, half-advanced, and advanced farming. Local farmers dominantly relied on mixed farming and shifting cultivation, and the objective of this farming mostly aimed to fulfill the basic household needs, which also known as survival agriculture. Meanwhile, transmigrant farmers dominantly applied sedentary, subsistence, semi-advanced, and advanced farming that it not only to fulfill the household's consumption but also to increase income and commercially meet the market demand [6].

The current industrial revolution should be able to increase food production based on the utilization of advanced technology, but in the Papua border region, most of the households of farmers still established non-technology-based farming. Based on the map of food security and vulnerability for the province of Papua in 2015, 37 districts (23.72%) experienced a surplus of the normative consumption to production ratio, while 119 districts (76.28%) experienced a deficit. In terms of food security, food availability will have an impact on the level of community, as well as the farmer house. The purpose of this study is to determine the factors that influence the level of food security of farmer households in the border region in the era of industrial revolution 4.0.

1. Method

1.1. Location and samples

Jayapura city and Keerom regency were chosen intentionally as the research locations considering that the two districts were easy to reach by land transportation. Other than that, farming land was relatively closer to the border area, and farmers cultivated varies of crops, such as sweet potatoes, rice, corn, and sago. The sample determined based on two main groups, which are the local and the transmigrant farmer. Local farmer households represent farmers who do not grow rice, while transmigrant households represent farmers who grow rice. Furthermore, sampling from each group was carried out by simple random sampling. The number of samples from local farmer households and transmigrant farm households is 80 households respectively, so the total respondents are 160 households.

1.2. *Data analysis method*

Analysis of factors that influence farm household food security was carried out by the *Ordinal Logit Regression* analysis. The ordinal logit model is a regression model where the dependent variable is qualitative which has more than two categories of categories and has a rating [7]. The approach is logistical probability (logit). The dependent variable category in this study is food-secure households

(value = 3), households with less food secure, (value = 2) and households that are not food-secure, (value = 1). The model estimated for farmer households is as follows [7]:

$$Logit\ (P1) = Log\frac{p1}{1-p1} \quad = \alpha 1 + \beta' X \tag{1}$$

$$Logit\ (P1 + p2) = Log\frac{p1+p2}{1-p1-p2} = \alpha 1 + \beta' X \tag{2}$$

$$Logit\ (P1 + p2 + \cdots + pk) = Log\frac{p1+p2+\cdots+pk}{1-p1-p2-\cdots-pk} = \alpha 1 + \beta' X \tag{3}$$

Where: P1 is the probability of households not being food-secure, P2 is the probability of households having less food secure and P3 is the probability of food secure households.

An important interpretation of the ordinal logit regression model is the odds ratio, namely the probability ratio of existing households. The estimation of the logit model is done by the Maximum Likelihood (ML) method. In this study, food-secure households determined as a base of reference (base/reference category) are. The form of odds ratios in natural logarithms (ln) for farmer households are as follows:

$$\ln\left(\frac{P_{i1}}{P_{i3}}\right) = \beta_{01} + \beta_{11}X_1 + \beta_{21}X_2 + \beta_{31}X_3 + \beta_{41}X_4 + \beta_{51}X_5 + \beta_{61}X_6 + \beta_{71}X_7 + \beta_{81}X_8 + \beta_{91}X_9 + \beta_{10.1}D_{Ras} + \beta_{11.1}D_{TL} + e_{i1} \tag{4}$$

$$\ln\left(\frac{P_{i2}}{P_{i3}}\right) = \beta_{02} + \beta_{12}X_1 + \beta_{22}X_2 + \beta_{32}X_3 + \beta_{42}X_4 + \beta_{52}X_5 + \beta_{62}X_6 + \beta_{72}X_7 + \beta_{82}X_8 + \beta_{92}X_9 + \beta_{10.2}D_{Ras} + \beta_{11.2}D_{TL} + e_{i2} \tag{5}$$

Description: Probability of Pi1 (P (Y = 1) if the household does not food secure, Pi2 Probability (P (Y = 2) if the household is less food-secure, Pi3 probability (P (Y = 3) if the household is food secure, X1 : income (Rp.), X2: land area (Ha), X3: education level of housewives (years), X4: number of household members (people), X5: average price of rice (IDR / kg), X6: average price of cassava (IDR / kg), X7: average price of cooking oil (IDR / liter), X8: Distance to buy food (Km), X9: average price of instant noodles (IDR / pack) , D_RAS = Dummy *raskin* (1: *raskin* recipient, 0: *raskin* non-recipient), D_TL = Dummy population status (1: transmigrant farmer, 0: local farmer), β0 : intercept, and β1-β20 : regression coefficient.

To measure the ordinal logit regression model, it is determined from:

a. Test -2Log Likelihood statistics (-2LogL) with Chi-Square distribution (X^2) with free degrees n-k. If the independent variable added to the model produces a value of -2LogL lower than the model with only constants with X^2 count> X^2 table then the model received is appropriate.
b. The Pseudo R-Square value (R^2) explains the variation in food security can be determined by the variation of the independent variable indicated by the R^2 Negelkerke value: $\boldsymbol{R^2N} = \frac{\boldsymbol{R_{CR}}}{\boldsymbol{1-[L(0)]^{2/n}}}$ [8]
c. Test parallel lines used to accept whether all categories have the same parameters or not. The desired value is P > 0.05 [7].

2. Results and Discussion

2.1. Characteristics of Respondents.

The characteristics of farmer households consist of the age of the head of the family, the level of education of the family head, the level of education of the mother, the number of family members, the area of land owned, and the area of land cultivated, that presented in the following table.

Table 1. Characteristics of farmer's households in the Papua border area

Characteristics	Average
Age of The Head of The Family (Year)	42.35
Education Level of The Head of the Family	SMP[1]
Education Level of The Mother	SMP
Number of Family Members (People)	3.18
Owned Land Area (Ha)	1.40
The Area of Cultivated Land (Ha)	1.20
Household Category	∑ Household
Number of food-secure households	90
Number of households is less food-secure	60
Number of households are not food secure	10

Source: Primary Data 2017
[1]Middle School

Table 1 shows that farmer households in the Papua border region are at a productive age. The level of education of the head of the family and mother is at the junior high level. The number of family members is small. The area of land owned and cultivated is less than 2 ha, meaning that households farming is small. Most households are in the food secure category.

2.2. Factors that affect the food security of farmer households in the border region.

Factors that allegedly affect food security of farmer households in the border region are the price of cooking oil, the price of sweet potatoes/cassava, the price of instant noodles, the share of food expenditure, the number of family members, cultivated land area, income, *raskin* and farmer status (local or transmigrant). Table 2 shows that the model if only using intercept alone produces a value of -2 log likelihood of 262.25, whereas if the independent variable is included in the model, decreases the value of -2 log likelihood to 226.07 with a significance value of 0.00, meaning that the model is fit. Nagelkerke's Pseudo R-Square value is 25.20%, which means that the income of the farmer's household, the number of family members, the area of land cultivated, the price of rice, the price of cooking oil, the price of noodles, the distance in obtaining food, food expenditure, the level education, *raskin* dummy and farmer's dummy status can explain the variation of farmer's household food security by 25.20%, while the remaining 74.80% is explained by other variables outside the model. The parallel line test value shows a significance value of 0.58> 0.05, the model matches or the model link function is used accordingly.

Cutoff value in Table 2 shows the distribution of farmer household food security level categories in the Papua border region as follows: probability of farmer households not food-resistant: Pr (KT <-7.09), probability of farmer households lacking food security: Pr (-7,09 <KT≤ -3,88) and the probability of food-resistant farming households: Pr (KT> -3.88). Table 2 also shows that the significant independent variables at $\alpha = 0.05$ are the number of family members, the price of rice, the area of land cultivated and the share of food expenditure, while the significant variable at $\alpha = 0.1$ is the *raskin* dummy.

Table 2. Parameter of Factor-Factor Estimation Affecting Household Food Security of Farmers in the Papua Border Region

Variable	Estimate	Sig.	Odds Ratio	% Odds Ratio
[FS = 1.00]	-7.09	0.01		
[FS = 2.00]	-3.88	0.16		
Cooking oil prices	0.01	0.57	1.01	0.80
Cultivated land area*	1.07	0.04	2.98	192.71
Distance to buy food	-0.09	0.32	0.917	-8.33
Share of food expenditure*	-0.53	0.03	0.59	-41.14
Number of family member*	-0.38	0.00	0.68	-31.61
Sweet potato/cassava prices*	-0.01	0.00	0.99	-1.39
Instant noodle prices	0.01	0.23	1.01	1.21
Income	0.00	0.52	1.00	0.00
[D_Raskin=.00]**	0.64	0.09	1.89	89.84
[D_Raskin=1.00]	0[a]	.		
[D_Lokal-Transmigrasi=.00]	-0.06	0.88	0.95	-5.35
[D_Lokal-Transmigrasi=1.00]	0[a]	.		
Model Fitting Information	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	262.45			
Final	226.07	36.36	10	0.00
Pseudo R-Square Nagelkerke	0.25			
Test of Parallel Lines	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	226,065			
General	217,529[a]	8,536[b]	10	0,577

Link function: Complementary Log-log.

*. Significant at α =5% **. Significant at α =1 % FS : Food Secure

The estimation results show that there are positive and negative odds ratio. If you pay attention to the significance value, the odds ratio, and the percentage odds ratio and assume other variables, then the estimation of logit regression of Table 2 can be interpreted as follows.

2.2.1. Positive Odds Percentage. The cultivated area and *raskin* dummy have positive odds percentages. The odds of the cultivated land area is 2.93, which means that an increase of 1 ha of land area cultivated by farmer households causes an increase in the probability of the farmer's household food security level by 2.93 times the previous value. The average area cultivated by farmers is 1.21 ha. When compared between the area of land cultivated by local farmers and transmigrant farmers, the area cultivated by transmigrant farmers is wider than 0.22 ha. The average area of land cultivated by local farmers is 1.10 ha while the land cultivated by transmigrant farmers is 1.32 ha.

Dummy *raskin* has an odds value of 1.89. The percentage of the odds of 89.84 means that the existence of *raskin* can increase the probability of the level of food security by 89.84%. As stated by [9], that the existence of the *Raskin* program caused a shift in food consumption from cassava to rice.

This can happen because the price of *raskin* rice is cheaper and easier to obtain because farmers no longer have to grow their own rice.

2.2.2. Percentage of Negative Odds. Variables that have a percentage value of the negative odds ratio are the variable number of family members, the price of sweet potatoes and the percentage of food expenditure. The number of family members has an odds ratio of 0.684, this means that the increase in the number of family members will reduce the probability of the farmer's household food security level by 0.684 times the previous value. Or if it is seen from the percentage of the odds value, it can be interpreted that the increase in the number of family members will reduce the odds of the ratio of the level of food security of household farmers by 31.614%. The number of family members has a role in the amount of food to be consumed. The price of jelly has an odds ratio of 0.986, which means that an increase of 1 rupiah from the price of sweet potatoes will reduce the probability of the level of food security of farmer households by 0.986 times than before. It can also be interpreted that the increase in sweet potato prices will reduce the probability of household food security by 1.39%. Sweet potatoes are consumed more by local farmers, considering that their staple food is initially sweet potatoes.

The odds ratio of the variable percentage of food expenditure is 0.589, meaning that an increase of 1 rupiah in food expenditure will reduce the probability of the level of food security of farmer households by 0.589 times the previous value. It can be said also that if the percentage of food expenditure increases it will reduce the odds of the level of household food security of farmers by 41.14%. According to Engel's Law, the share of food expenditure on household expenditure will decrease with increasing income (Deaton and Muellbauer, 1980)[10]. The smaller the share of food expenditure, the more resistant households are to food. The average food expenditure of farmer households in the border region is Rp. 1,887,175, - with a share of food expenditure of 52.78%. The share of farmers' household food expenditure is lower than 60%, this can show that farmer households are quite food-resistant.

The form of odds ratios in natural logarithms (ln) for farmer households are as follows:

$$\begin{aligned}\ln(p1) = {} & -7.09 + 0.008\ cooking\ oil\ prices + 1.074\text{Cultivated land area} \\ & - 0.087\text{Distance to buy food} - 0.530\text{Share of food expenditure} \\ & - 0.380\text{Number of family member} - 0.014\text{Sweetpotato or cassava prices} \\ & + 0.01\text{Instant noodle prices} + 0.000\ \text{Income} + 0.641 D_Raskin - 0.055\text{D_Lokal} \\ & - \text{Transmigrasi} + \quad e_{i1} \\ \ln(p1 + p2) = {} & -3.88 + 0.008\ cooking\ oil\ prices + 1.074\text{Cultivated land area} \\ & - 0.087\text{Distance to buy food} - 0.530\text{Share of food expenditure} \\ & - 0.380\text{Number of family member} - 0.014\text{Sweetpotato or cassava prices} \\ & + 0.01\text{Instant noodle prices} + 0.000\ \text{Income} + 0.641 D_Raskin - 0.055\text{D_Lokal} \\ & - \text{Transmigrasi} + \quad e_{i1}\end{aligned}$$

3. Conclusion

Most of the household farmers classified as the food secure condition. Partially the number of family members, cultivated land area, the share of food expenditure and the price of sweet potato/cassava have a significant effect the probability of the occurrence of food security for farmer households significant at the 5% level of error, while dummy *raskin* significant at an error rate of 10%. The cultivated land area and dummy *raskin* have a positive effect on the food security of farmer households, while the number of family members, the price of sweet potato/cassava, and the share of food expenditure have a negative effect on farm household food security.

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