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REGRESSION MODEL ON PAGARALAM COFFEE FARMERS' INCOME WITH THE INFLUENCE OF THE USE OF HERBICIDE REDUCTANT VARIABLE

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Abstract. *The existence of weeds in coffee fields will become competitors for coffee plants, so that they can be economically and ecologically detrimental. Inappropriate use of chemical herbicides can have a negative impact. Herbicide reductants made from organic are used in weed control. This study aims to analyze the variables that affect the net income of Pagaralam coffee farmers using multiple linear regression analysis. One of these variables is a qualitative variable in the form of categories of respondents based on the use of herbicide reductants. The data used was obtained from the results of questionnaires on 56 respondents who are users and 80 respondents who are not users of herbicide reductants. The results of the hypothesis test of mean difference found that the net income of the two respondent categories is not different. The regression analysis also resulted that there was no significant difference in net income between the two respondent categories. Variables that had a significant effect on net income included gross income, farming maintenance costs, estimated yields, and tree age. Several models also contain variables of land area, length of time in coffee farming, number of trees, and frequency of organic fertilizers used. Old coffee trees should be treated better with the use of organic fertilizers and also wise weed control techniques.*

Keywords: *herbicide reductant, income, Pagaralam coffee, qualitative variable, regression model.*

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1. INTRODUCTION

Coffee is one of Indonesia's leading export commodities. Several analytical methods, namely Computable General Equilibrium (CGE) and Export Product Dynamics (EPD) resulted that coffee ranks 8th. Coffee is the fourth largest foreign exchange earner after palm oil, rubber and cocoa. Sustainable land farming maintenance needs to be considered [1].

South Sumatra Province is the largest robusta coffee producer in Indonesia [2]. Based on 2020 estimates, South Sumatra's contribution to the total national coffee production was 25.8%. Pagaralam is one of the coffee-producing cities/districts in South Sumatra, which occupies 3.3% (6^{th} order) of the South Sumatra coffee area but contributes 11.3% (4^{th} order) of South Sumatra's coffee production and has the highest average production of 2,890 kg/ha, which is 3,169 times the average production of South Sumatra coffee.

The coffee plant around Mount Dempo in the Pagaralam City area is one of 4 superior varieties of robusta coffee, the productivity of which can be more than 2 tons/ha [3]. If seen from data [2], Pagaralam in 2018 had the average amount of production per 1 ha of land area was $\frac{21{,}893}{8{,}323}$ = 2.63 tons/ha and the average amount of production per 1 ha of Mature Plant area was $\frac{21{,}893}{7{,}576}$ = 2.89 tons/ha. This shows that the productivity of coffee plantations in Pagaralam is very high.

The amount of coffee production is one of the factors that affect the income of coffee farmers. In addition to production, there are several other factors that affect the income of Pagaralam coffee farmers, including land productivity [4], frequency of herbicide and fertilization applications [5]. [6] examined the effect of the variables of income, capital, total production, education, and coffee farming experience on farmers' decisions to adopt a diversification pattern in each village in Pagaralam City, Lahat District, and South OKU District. By regression analysis, the factors that have a significant effect are education and farming experience.

The presence of weeds around coffee plants will indicate plant morphological abnormalities, including small fruit, low production and symptoms of nutrient deficiency. In controlling weeds, it is necessary to know the dominant weed type, control alternatives, economic, ecological and parasitic impacts [7]. The right dose of herbicide will kill the target weeds, but if it is too high it can damage or even kill the cultivated plants. Weed vegetation analysis needs to be done to determine the composition of the dominating vegetation in order to determine the appropriate control [8].

Research on the effectiveness of herbicides with various treatments needs to be carried out so that they are used in the right dose, at the right time, and on target. According to [9], a non-selective herbicide with the active ingredient glyphosate is considered quite active and efficient in chemical weed control. Integrated pest management, weed control, and application of safe use of pesticides in demonstration plots are 3 of TechnoServe's Farm College training project curriculum to improve the skills of coffee farmers in Latin America [10]. Weed control can also use mulch. Sustainable land management can be done by raising awareness through participatory extension methods, such as Farmer Field Schools [11]. Shade trees can suppress the growth of weeds, withstand the wind and ecologically as a water catchment. In addition, shade trees have economic benefits in agroforestry systems [12].

A small number of farmers are not aware that the use of herbicides that are not properly dosed and not suitable for target weed control can have a negative impact on coffee production. Most believe that the dominant influences on coffee production are the weather which is too much rain and the coffee berry borer pest. As mentioned in [3], one of the characteristics of robusta coffee is that it has shallow roots, so weed control is very influential on coffee plants.

Several studies discuss the factors that affect the production and income of coffee farmers, including: [13] using a regression model on the effect of 10 variables including land area, number of trees, use of herbicides, pesticides, labor, manure, urea, SP36, KCL, and ZA on Arabica coffee productivity (kg/ha) in Enrekang. [14] used regression analysis for Arabica coffee production (kg) in Husundutan on 4 variables, namely land area, number of farms, development of domestic and international coffee prices. [15] compiled a coffee production function by using the Cobb-Douglass regression model on 4 variables, namely the number of workers, land area, plant age, farmer experience. [16] used the mean difference test to compare the income of arabica coffee farming in monoculture and intercropping. [17] used a coffee production regression model based on 4 variables, namely land area, business capital, coffee price, and farmer education. [18] used path analysis to examine the effect of agricultural production, land area, and education on land conversion farmers' incomes in Bali.

Regression is the study of how one dependent variable is affected by one or more independent variables. The purpose of regression is to estimate or predict the mean value of the dependent variable based on the known value of the independent variables ([19] - [21]). In regression, there are two types of variables, namely quantitative variables (in numeric form) and qualitative variables (in non-numeric form, usually in the form of attributes). These qualitative attributes must be quantified first using the dummy variable technique. The significance of the dummy variable affects the magnitude of the value of the intercept or constant in regression model. The dummy variable regression coefficient is a differentiating coefficient between variables that have attributes and variables that do not have attributes.

In 2019, Serambi Indonesia Daily reported that a number of buyers in Europe began to reject exported Gayo coffee, because samples of Gayo Arabica coffee were found to contain glyphosate [22]. This of course must be a concern for farmers so that in the long term it will not have an impact on coffee as an export commodity which is a source of state income. Pesticide reductant is a product made from organic as a pesticide reducer, so it can reduce pesticide residues in agricultural areas as well as more economical because it can reduce pesticide costs. Since mid-2018, several groups of Pagaralam coffee farmers have begun to recognize pesticide reductants. Locally made pesticide reductants which are claimed to be relatively non-toxic and dangerous [23]. A mixture of reductants in pesticides can save farm or plantation maintenance costs by at least 10 percent to 40 percent [24].

In [25], there were more than 1,000 farmers belonging to 43 farmer groups in South Sumatra that have used reductant products. In early 2021, based on interviews with a distributor of agricultural depot in Pagaralam City and related private parties, there were around 500 – 1,000 users of herbicide reductants in Pagaralam and its surroundings (including villages that entered the Lahat District area). There are some villages where most farmers are quite loyal to using herbicide reductants.

Farmers' lack of knowledge and lack of education have resulted in serious problems for the land and coffee plants, thus affecting coffee production. Most of the coffee trees in Pagaralam are more than 20 years old, because it is a hereditary farming business. Traditional replanting, lack of fertilization efforts, and unwise use of herbicides can affect land conditions, the health of coffee plants, and of course coffee production. Unhealthy coffee trees and lack of nutrients that can be absorbed by plants can cause plants to be susceptible to pests, reduced quality and quantity of coffee cherries, thereby reducing the income of coffee farmers. To improve the condition of land and plants like this, of course, requires time and good care. In [26] and [27], by using bivariate analysis on 214 respondents, it was found that the frequency of herbicide use is one of the factors that affect land productivity (i. e. production per unit area of land) of Pagaralam coffee. According to [28], only 20% of the respondents did not use herbicides. There were 53% of respondents who applied herbicides together with the use of fertilizers. In these studies, no attention was paid to the use of reductants.

Reductant products are used by farmers through a process of education and assistance from related parties. Of course, this can change the mindset and culture of Pagaralam coffee farming through education about the importance of sustainable agriculture, which is environmentally friendly. Based on [29], the area per 1 tree, the age of the tree, the maximum selling price of coffee beans, the number of workers in the family, workers outside the family, both male and female, the mean values are not the same between respondents who used and respondents who did not use herbicide reductants. This is based on 125 respondents, by not examining variables related to the coffee production and income of respondents.

This study aims to analyze the variables that affect the net income of Pagaralam coffee farmers. In addition, this study also aims to analyze whether there is an effect of differences in the characteristics of farmers using reductants with farmers who have not or have just tried using herbicide reductants on their net income. The method used is regression analysis with a qualitative variable as one of the independent variables. The variables used include the socio-economic side of farmers and the culture of land processing, land conditions related to coffee farming, crop production, and external factors of coffee bean prices. The result of this study is a model with independent variables that have a significant effect on the net income of Pagaralam coffee farmers. Variables that have positive or negative effects can be a reference for efforts to increase income from Pagaralam coffee farming. Analysis of the effect of the use of herbicide reductants on net income, can also be used as a reference for sustainable management of Pagaralam coffee plantations.

2. RESEARCH METHODS

The data used in this study is based on questionnaire data from farmers who run Pagaralam coffee farming businesses. The questionnaire questions have been tested for validity and reliability. The sampling of respondents as data samples is assumed to be random. But the reality on the field, the selected respondents are respondents who are easy to find at the right time and place and are relatively easy to participate as respondents. These respondents are owners of farming land and also involved in caring for and selling their coffee beans.

Data collection in the field was carried out from July to early September 2021. The variables studied included internal factors in terms of respondents' identities and coffee plantations, land management, production, farmers' income, and green beans prices as external factors. Furthermore, respondents were divided into 2 categories, namely users and non-users of herbicide reductants. The data processing method used is multiple linear regression analysis, which was previously also did the hypothesis testing as information regarding the comparison of the mean variable values for each category of respondents. Data processing is assisted by Minitab 19 and SPSS 24 software. The steps taken in data processing are:

1. Perform hypothesis testing on the comparison of the mean of each variables of two coffee farmers categories.
2. Determine the correlation coefficient between variables.
3. Analyze highly correlated variables.
4. Perform multiple linear regression analysis on all independent variables, including qualitative variables in the form of respondent categories, namely:

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_k X_{ik} + \varepsilon_i \qquad (1)$$

where $\beta_0, \beta_1, \ldots, \beta_k$: parameters,
$X_{i1}, X_{i2}, \ldots, X_{ik}$: known constants, and
ε_i: independently error with normal distribution $N(0, \sigma^2)$; $i = 1, 2, \ldots, n$. [19]
4.1 Perform multiple linear regression analysis thoroughly with the enter method.
4.2 Perform multiple linear regression analysis gradually using stepwise, backward, and forward methods.
4.3 interpretation of the results from Step 4.1 and Step 4.2 for independent variables that have a significant effect based on statistical tests through the results of ANOVA (F test), t test, and R^2.
4.4 interpretation of the influence of qualitative variables from 2 categories of respondents
5. Perform regression analysis on each independent variables and a qualitative variable in the form of respondent categories.
6. Interpret the results of Step 5 and compare them with the results of Step 1 and Step 4.4 to analyze that there are relationship between respondent categorization and independent variables on net income.
7. Testing the OLS (Ordinary Least Squares) assumption in the regression model as the result of Step 4 where the independent variables in the model have significant effects. The OLS assumption test includes heteroscedasticity, autocorrelation, and normality.
8. Compile conclusion.

3. RESULTS AND DISCUSSION

There were 136 respondents as samples in this study. The respondents were divided into 2 categories, namely respondents who used herbicide reductants (denoted as 1) and respondents who did not or had just started trying to use herbicide reductants (denoted as 0). The number of respondents for non-users (denoted as n_1) were 80 people and 56 reductant users (denoted as n_2). There are 21 variables studied, which also include production and income variables. Some of the results of hypothesis testing for the difference in mean and variance in the comparison of the two categories of respondents can be seen in Table 1. This hypothesis testing is based on the assumption that the two populations are normally distributed, but the standard deviation is unknown and the number of samples is more than 30. It is also assumed that the sample was chosen randomly. In this case, hypothesis testing uses the Z and F distribution tests.

Table 1. Hypothesis testing for differences in mean and ratio of variance in two categories of respondents

No.	Variable	0 and 1	Mean	StDev	Median	Z_{count}	F_{count}	Description
1	Ages	0	44.19	11.82	45.00	0.68	1.36	Accept H_0
		1	42.91	10.14	42.00			
2	Education	0	10.688	3.484	12.000	1.87	1.23	Accept H_0
		1	9.482	3.861	9.000			
3	Length of farming experience	0	21.26	12.49	21.50	-0.71	1.28	Accept H_0
		1	22.71	11.03	23.00			
4	Land area	0	1.1563	0.5327	1.0000	-1.77	2.41	* Accept H_0
		1	1.379	0.827	1.000			
5	Number of trees	0	3646	1704	3500	-0.68	2.26	* Accept H_0
		1	3911	2564	3500			
	…	…	…	…	…	…	…	…
21	Frequency of herbicide use	0	2.0500	0.7274	2	-2.53	1.17	Reject H_0
		1	2.3571	0.6723	2			

*Note: The critical Z for $\alpha/2$ = 5% is 1.65; α /2=2.5% is 1.96. The critical F value uses α = 5%. *Meaningly reject H_0 on the F test. The two-tailed hypothesis test on H_0 states that the mean of the two populations is the same. The two populations are assumed to be independent with the Z test statistic. $Z_{count} = \frac{\overline{X_1}-\overline{X_2}}{\sqrt{\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}}}$ and $F_{count} = = \frac{s_1^2}{s_2^2}$. In the value of F_{count}, the large sample variance is placed in the numerator, while the small sample variance is placed in the denominator.*

On Table 1, the mean difference hypothesis test resulted that the mean of two categories of respondents were not the same in terms of tree age, minimum selling price of coffee beans, maximum selling price of coffee beans, use of Workers from Outside the Family (denoted as TL), length of harvest period, and frequency of herbicide use. Respondents using herbicide reductants had the mean value of these variables higher than non-user respondents, except for the maximum price of coffee beans. Meanwhile, based on the comparison ratio of variance test, there were differences in variance from the two respondents, namely on the variables of land area, number of trees, frequency of organic fertilizers used, average selling price of coffee beans, TL, length of harvest period, and land productivity. Respondents using herbicide reductants had a higher variance for these variables than non-user respondents, except for the average price of coffee beans.

Based on the correlation between the variables studied, there are several variables that have a high correlation to net income, namely land area, number of trees, total harvest, coffee bean production, and gross income. These correlations can be seen in Table 2. The variable which has a high correlation to land productivity is the average production (in kg/10^4 trees). Workers from inside the family (denoted as TD) are dominated by men, and conversely workers from outside the family are dominated by women.

Table 2. Variables that have moderate to high correlation and their correlation values

Variable	Variable	Correlation coefficient
Length of farming experience	Age	0.853
Gross income	Land area	0.549
Net income	Land area	0.572
Gross income	Number of trees	0.612
Net income	Number of trees	0.625
Farming maintenance costs	Coffee bean production	0.534
Gross income	Coffee bean production	0.884
Net income	Coffee bean production	0.870
Gross income	Total harvest	0.760
Net income	Total harvest	0.752
Average price of coffee beans	Minimum price of coffee beans	0.625
Average price of coffee beans	Minimum price of coffee beans	0.555
Gross income	Farming maintenance costs	0.563
Net income	Gross income	0.946
TD	TDL	0.806
TL	TLL	0.872
TL	TLW	0.905
TLL	TLW	0.588
Land productivity (in kg/10^4 m^2)	Production average (in kg/10^4 trees)	0.743

Furthermore, an analysis of the variables that affect the net income of coffee farmers is carried out and also whether there is a difference in the net income of the respondents in terms of the use of herbicide reductants. Qualitative variables in the form of users and non-users are expressed as dummy variables. The following Table 3 presents multiple regression on "all" standardized and unstandardized independent variables.

Table 3. Recapitulation of the regression model on net income

No	Regression	Independent variables that are significant from *t*-test	Constants of 0 and 1, Coefficient of Dummy-1	R^2 and R^2- (in %)	Durbin-Watson (*d*)
1	All independent variables	Age of tree Estimated yield Farming maintenance costs Gross income	-3438776 -2666616 772160	94.93 93.41	2.075
2	All standardized independent variables	Age of tree Estimated yield Farming maintenance costs Gross income	-3438776 -2666616 772160	94.93 93.41	
3	Stepwise results*	Length of farming experience Land area Age of tree Estimated yield Farming maintenance costs Gross income		94.30 94.04	2.057
4	Backward results*	Number of trees Age of tree Estimated yield Farming maintenance costs Gross income	772160	94.08 93.85	2.057
5	Forward results*	Length of farming experience Land area Age of tree Estimated yield Freq. of organic fertilizers Farming maintenance costs Gross income		94.39 94.08	2.116
6	Eight "influential" independent variables (that are standardized)	Length of farming experience Age of tree Estimated yield Farming maintenance costs Gross income	1010036 1007309 -2727	94.39 93.99	
7	Eight "influential" independent variables (that are unstandardized)	Length of farming experience Age of tree Estimated yield Farming maintenance costs Gross income	1010036 1007309 -2727	94.39 93.99	2.125
8	Seven "influential" independent variables (that are unstandardized)	Age of tree** Estimated yield	1889859 2192020 302161	75.65 74.11	1.869
9	Seven "influential" independent variables (that are standardized)	Estimated yield	1889859 2192020 302161	75.65 74.11	
10	All independent variables, but without categorization of respondent (both standardized and not)	Age of tree Estimated yield Farming maintenance costs Gross income		94.87 93.45	

*Remarks: * standardized independent variables. ** t test and F test were performed at $\alpha = 10\%$.*
Notation 0 for non-user respondents and 1 for reductant user respondents.

Dummy-1 as user or non-user qualitative variable.
Unstandardized coefficient is used to the significance test of the independent variables. Standardized coefficient is a regression coefficient calculated from the data of independent and dependent variables that have been converted into a normal distribution, due to different measurement scales. In this case the constant (or intercept) becomes zero.

The regression models in Table 3 are denoted as Model 1 to Model 10. The F test which results in the rejection of H_0 shows that simultaneously all independent variables affect net income. The F test on all models resulted in the rejection of H_0. While the rejection of H_0 on the t-test shows the partially influence of independent variables on net income. Figure 1 shows an example of some of the regression analysis outputs on model 1 by using Minitab 19 software. The display in Figure 1 includes the significance test of the model through the t test, F test, and the coefficient of determination as goodness of fit in regression model.

Coefficients

Term	Coef	SE Coef	T-Value	P-Value
Constant	- 3438776	6418529	-0.54	0.593
Age	46649	52478	0.89	0.376
Education	-92861	67794	-1.37	0.174
...				
Age for first farming	-56636	67480	-0.84	0.403
Planting area	435573	604416	0.72	0.473
Age of trees	-85901	27897	-3.08	0.003
Estimated yields	**284160**	**101510**	**2.80**	**0.006**
Frequency of herbicide use	-159917	315399	-0.51	0.613
...				
Farming maintenance costs	**-0.617**	**0.139**	**-4.45**	**0.000**
Gross income	**0.7131**	**0.0507**	**14.06**	**0.000**
...				
Reductant users/Non-Users 1	**772160**	756696	1.02	0.310

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	31	8.94031E+15	2.88397E+14	62.24	0.000
Error	103	4.77268E+14	4.63367E+12		
Total	134	9.41758E+15			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2152597	94.93%	93.41%	80.08%

Figure 1. Partial output of regression analysis on Model 1 by using Minitab 19 software

In model 1, such as Equation (1), the resulting model for respondents who are not reductant users is:
Net income = -3438776 + 46649 Age - 92861 Education - 56636 Start coffee farming + … - 249136 Length of harvest + … + 90 Average production (kg/10,000 trees)
While the model for reductant users is:
Net income = -2666616 + 46649 Age - 92861 Education - 56636 Starting coffee farming + …-249136 Length of harvest + … + 90 Average production (kg/10,000 trees)

The goodness of fit model through the coefficient of determination, R^2, is 94.93%, indicating that the variation in net income is explained by variations in all independent variables of 94.93%, the remaining 5.07% is explained by other variables. The significance test of the model through the F test, the calculated F value is 62.24 and the p-value is 0.00, then it rejects H_0, meaning that simultaneously the independent variables have an effect on net income. The significance test of the independent variables with the t value shows that the independent variables of tree age, estimated yields, farming maintenance costs, and gross income have a significant effect on net income.

Furthermore, the same interpretation is also carried out for the other regression models. The output of the regression analysis using the stepwise, forward, and backward methods in Table 2, there are 8 independent variables that have a significant effect on net income, namely: length of coffee farming, land area, age of tree age, number of trees, estimated yield, frequency of organic fertilizers used, farming maintenance costs, and gross income.

The coefficient value of the qualitative variable (i.e. category of users/non-users of reductants) on the t-test with $\alpha = 5\%$ indicates that the variable has no effect on net income. The coefficient of the reductant user variable shows the large difference in net income of reductant users to non-users, but the difference is not significant at $\alpha = 5\%$. This can be interpreted that respondents who use or do not use reductants have a net income that is not significantly different. This can also be seen in Model 10 that is without the qualitative variable, the obtained R^2 model remains high, which is 94.87%.

In Model 1 and Model 2, the magnitude of the difference in the coefficient of the qualitative variable is 772,160 (in IDR; that is, -2,666,616 - (-3,438,776)). In Model 1, this value can show that the average net income of reductant users is 772,160 (in IDR) higher than that of non-users, assuming the other independent variables are constant. While in Model 6 and Model 7 (on 8 independent variables), the difference in the coefficients of the qualitative variable is very small, namely -2,727 (i.e. 1,007,309 - (-1,010,036); in IDR). In this Model 7, net income reductant users are 2,727 (in IDR) lower than the net income of non-users with the assumption that other variables are to be constant. In Model 8 and Model 9 (i.e. on 7 independent variables without gross income variable), the difference is 302,161 (in IDR). In Model 8, the net income of reductant users is 302,161 (in IDR) higher than the net income of non-users with other variables assumed to be constant. So, the difference of net income in these two categories is very small and has no significant effect.

For example, the X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, and Y variables respectively denote the length of coffee farming, land area, number of trees, age of tree, estimated yield, frequency of organic fertilizers used, land maintenance costs, gross income, and net income. The correlation between independent variables that have a significant effect on net income in the regression model can be seen in Table 4. The correlation coefficient ranges from 0.051 to 0.915. Variables that have a high correlation are land area with the number of trees (i.e. 0.915), and estimated yields with gross income (i.e. 0.838). In each model, the variables of land area (X_2) and number of trees (X_3) do not simultaneously have a significant effect on net income (Y). On the other hand, it applies to the estimated yield variable (X_5) and gross income (X_8), which are variables that have a significant effect on net income in each model. If the gross income variable is eliminated from the model, then R2 can decrease from 94% to around 75%. Based on Model 8 and Model 9, if gross income is not included in the model, then R^2 will decrease to 75.65%.

Table 4. Correlation coefficient between an independent variable and gross income

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Land area (X_2)	0.268							
Number of trees (X_3)	0.308	**0.915**						
Age of tree (X_4)	0.215	0.220	0.074					
Estimated yield (X_5)	0.334	0.532	0.575	0.071				
Freq. of organic fertilizer used (X_6)	0.051	0.132	0.153	0.112	0.113			
Farming maintenance costs (X_7)	0.169	0.297	0.389	0.194	0.503	0.155		
Gross income (X_8)	0.272	0.549	0.612	0.090	**0.838**	0.210	0.563	
Net income (Y)	0.307	0.572	0.625	-0.011	0.847	0.146	0.401	0.946

The regression models by using the stepwise, backward, and forward methods result independent variables that have a strong correlation to the net income variable. The goodness of fit value of the regression model (R^2) generated by each model is more than 90%. The coefficient of determination will continue to increase with the increasing number of independent variables included in the model. In this case, an adjusted coefficient of determination (R^2-*adj*) can be used. In general, the regression model shows that the variation in net income can be explained by the significant independent variables by 94% and the remains (about 6%) is explained by other variables.

Table 5. Signs of the coefficient of variables that have significant effects on net income

Significant independent variables in the model	The sign on coefficient of variable							
	1	2	3	4	5	6	7	10
Length of farming			+		+	+	+	
Land area			+		+			
Age of tree	-	-	-	-	-	-	-	-
Number of trees				+				
Estimated yield	+	+	+	+	+	+	+	+
Freq. of organic fertilizers used					-			
Farming maintenance costs	-	-	-	-	-	-	-	-
Gross income	+	+	+	+	+	+	+	+

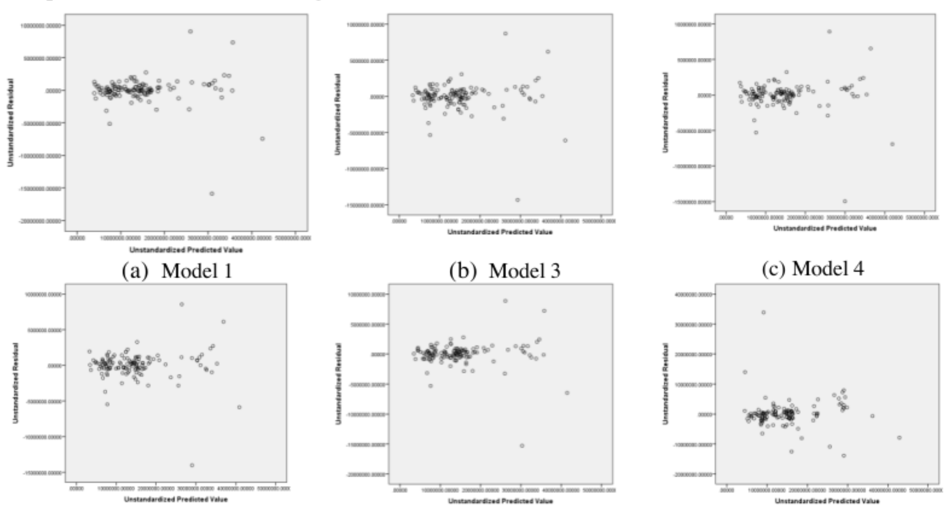
The sign of coefficient values of the significant variables in each model can be seen in Table 5. Variables that have negative effects are age of tree, frequency of organic fertilizers used, and farming maintenance costs. While the variables of length of farming, land area, number of trees, estimated yields, and gross income have positive coefficients. For example, the coefficient of age of tree in Model 1 is -85,901, meaning that if the age of tree increases by 1 unit, the net income will decrease by 85,901 (in IDR), assuming other variables are constant. In Model 2 (with standardized variables), the coefficient of the age of tree is -796,936, so it is the 7th largest effect on net income. Whereas in Model 9 (i.e. model with standardized variables and without the gross income variable), the coefficient of the age of tree variable is -752,358, so that it ranks the 3rd largest effect on net income, after the estimated yield (6,237,199) and the number of trees (1,507,172, but it's not significant). In general, the dominant independent variables (along with their sign of coefficients) that affect net income are gross income (+), farming maintenance costs (-), estimated yields (+), and age of tree (-).

In each model with standardized independent variables, except Model 9, gross income has the greatest effect on net income. If coefficients of the gross income variable that is unstandardized in model 1 (that is 0.7131) and model 10 (that is 0.7072) are compared, then in the model without categorization of reductant users shows a decrease in the magnitude of the effect of gross income on net income. Based on the standardized coefficients of the independent variables, the order of magnitude of the influence of the independent variables on net income is:

in model 2 : Gross income, Estimate yield, Farming maintenance costs, and Age of tree;
in model 3 : Gross income, Farming maintenance costs, Estimated yield, Age of tree, and Land area;
in model 4 : Gross income, Farming maintenance costs, Estimated yield, Age of tree, Number of trees;
in model 5 : Gross income, Farming maintenance costs, Estimated yield, Age of tree, Land area, Length of farming, and Frequency of organic fertilizer used;
in model 6 : Gross income, Farming maintenance costs, Estimated yield, Age of tree, and Length of farming;
in model 9 : Estimated yields and Age of tree;
in model 10 : Gross income, Estimated yield, Farming maintenance costs, and Age of tree.

Furthermore, the OLS assumption was tested on Model 1, Model 3, Model 4, Model 5, Model 7, and Model 8, where the independent variables were not standardized. This test was carried out on a model in which all independent variables had significant effects on net income. The assumption about heteroscedasticity can be seen in Figure 2. The assumption of normality can be seen in Figure 3.

The existence of autocorrelation can be seen from the Durbin-Watson statistical value (d) in Table 2. If the calculated value of d is close to 2, then in each model there is no autocorrelation. It can also be seen from the calculated value of d which lies between the critical value of the upper limit (d_U) and $4 - d_U$. The d_U value in the Durbin Watson table with α =5% for the number of samples n = 136 and the number of independent variables 2 to 7 ranges from 1.75 to 1.83.

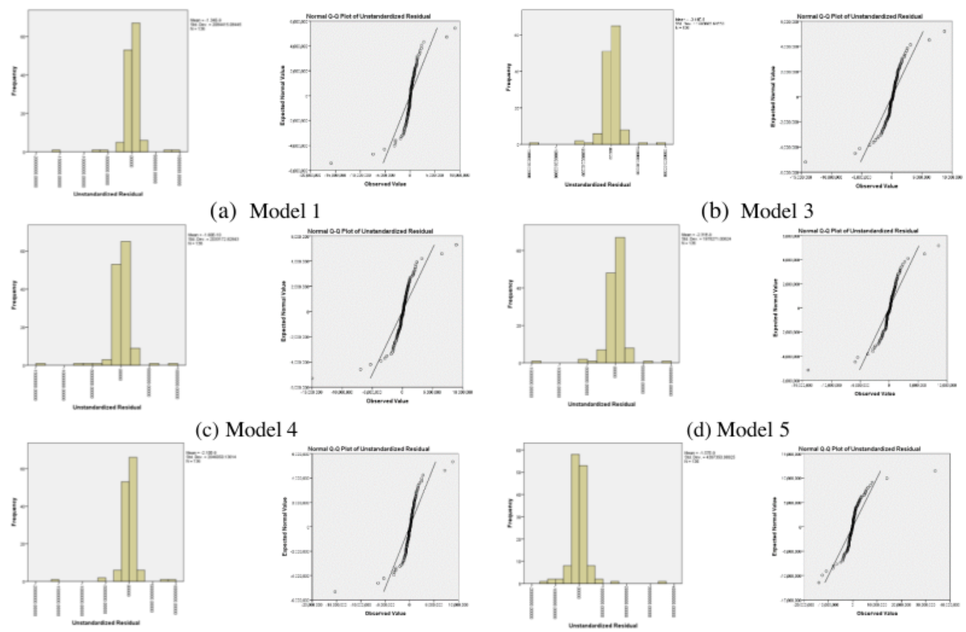


(a) Model 1 (b) Model 3 (c) Model 4

(d) Model 5 (e) Model 7 (f) Model 8

Figure 2. Plot of residuals to detect the assumption of homoscedasticity

Based on Figure 2, it can be seen that there is no pattern of correlation between the predicted value of the dependent variable (that is net income) and the residual. Thus, the residual can be said to be homoscedastic. On Figure 3, the histogram of the residuals shows a tendency to resemble the normal distribution curve, although there is a skewness that causes the curve asymmetry. The *Q-Q* plot shows that the *Q-Q* values are located slightly closer to the straight line, although some values are farther away from the straight line.



(a) Model 1 (b) Model 3

(c) Model 4 (d) Model 5

(e) Model 7 (f) Model 8

Figure 3. Histogram and Q-Q plot to detect the assumption of normality in the residual

To analyze the effect of an independent variable and the use of herbicide reductants variable on net income, regression analysis was carried out in each independent variable and a qualitative variable that consist of 2 categories. Table 6 shows all regression models where the results of the *F*-test and the *t*-test on independent variable has a *p*-value less than 0.05. The results of this *F* test indicate that simultaneously the independent variable and the qualitative variable of the respondent's category affect net income.

Based on Table 6, the independent variables that are significant to the net income variable are the age of respondent, length of farming, land area, number of trees, estimated yield, coffee bean production, total harvest, Farming maintenance costs, gross income, number of workers outside family (denoted as TL), TL-men, and TL-female. The *t* test on the qualitative variable shows that the respondent's category has no significant effect on net income, so that the net income of reductant users is not different from that of non-users. In the regression model where one of the independent variables is respondent age, land area, and estimated yield, it shows that reductant users have a slightly higher net income than non-users, assuming the independent variable is fixed. On the other hand, in the regression model with one of its independent variable is length of farming, number of trees, production of coffee beans, total harvest, farming maintenance costs, gross income, TL, TL-men, and TL-women, reductant users had a slightly lower net income than non-users, assuming the independent variable is fixed. Based on the coefficient of determination R^2-adj, variations in the estimated yield, coffee bean production, and gross income can explain the variation in net income of 71.35%, 75.51%, and 89.54%, respectively. While the other variables have very low R^2-adj.

Table 6. Regression analysis with qualitative variable

No	Independent Variable (as *X*)	Coefficient on *X*	Constant 0	Constant 1	Coefficient on 1	R^2 (R^2-*adj*) (in %)
1	Age of respondent	0.729	6850635	7346387	495751	5.17 (3.74)
2	Length of farming	0.980	9797499	9763027	-34472	9.39 (8.03)
3	Land area	0.274	6024505	4690180	1334325	33.3 (32.30)
4	Number of trees	0.739	5273215	4891122	-382093	39.2 (38.24)
5	Estimated yield	0.917	2137267	2218784	81517	71.8 (71.35)
6	Coffee bean production	0.271	1951430	1148709	-802722	75.9 (75.51)
7	Total harvest	0.862	2416187	2247432	-168755	56.6 (55.94)
8	Farming maintenance costs	0.828	10513345	10220659	-292686	16.1 (14.82)
9	Gross income	0.159	797972	130837	-667135	89.7 (89.54)
10	TL	0.813	10934373	10594894	-339474	6.8 (5.44)
11	TL-men	0.871	12435889	12203930	-231959	7.16 (5.76)
12	TL-women	0.572	13638878	12786935	-851943	4.5 (3.09)

Based on the results of the hypothesis test of the difference in the mean of the two categories of respondents in Table 1, the net income of the two respondents is not different. Variables with different mean values in the two categories of respondents include the age of the tree, the minimum selling price of coffee beans, the maximum selling price of coffee beans, the use of workers from outside the family (TL), the harvest period, and the frequency of herbicide use. Of the 6 variables, only the age of tree can have a significant effect on the regression model (even in each model 1 to model 10). However, based on Table 6, the age of tree is not a variable that has a significant effect on net income in the model with 1 independent variable and a dummy variable. Only the model with the TL variable has a significant effect on net income in that model.

Overall, when viewed from the real problem, there is no significant difference in net income between the two categories of respondents. The high average age of trees in respondents using reductants generally requires more intensive care. The length of the harvest period and the use of higher TL can be covered by other variables, namely estimated yields, land area, and number of trees. This may result in a slightly higher net income of herbicide reductant users than non-users.

4. CONCLUSIONS

The regression models obtained indicate that the qualitative variables of users and non-users of reductants have no significant effect on net income. The variables that have a significant effect on net income include gross income, farming maintenance costs, estimated yields, and age of tree. Some of the models also contain variables of land area, length of farming, number of trees, and frequency of organic fertilizers used, as variables that have a significant effect on net income. Gross income has the greatest effect on net income.

In further research, the comparison of net income and characteristics of Pagaralam coffee farmers can be analyzed based on 3 categories of respondents, namely users, just trying to use, and non-users of reductants. In addition, it can also be investigated the relationship between categorization of respondents on net income and land productivity by using logistic regression models, Cobb-Douglass functions, and correspondence analysis. The independence relationship between several variables and the categorization of respondents can also be analyzed further.

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