



Analysis of Microinsurance Demands Combined with Microcredit on Rice Farming by Using Utility Function

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Abstract

Agriculture is a business that is prone to risk and uncertainty so farmers can face serious difficulties at any time. Especially for farmers in developing countries who are generally small farmers. To anticipate these risks and uncertainties, farmers can take agricultural insurance or apply for credit. Even though an agricultural insurance program is available, farmers are constrained by the limited amount of collateral and liquidity constraints. This study aims to analyze the demand for microinsurance combined with microcredit in rice farming. The analysis is carried out with utility functions and utility comparisons using ordinal comparison. Meanwhile, to determine optimal demand by maximizing the utility using an ordinal approach through analysis of budget line and indifference curve. The results show that the demand for insurance and the profitability of agricultural credit increases along with the lower demand for collateral when applying for agricultural loans. In addition, microinsurance combined with microcredit is more profitable for farmers when collateral is not requested when applying for agricultural credit. Based on the results of the case study, the optimal demand is obtained when the premium for Rice Farming Business Insurance (AUTP) is Rp699.267,07 and the installments of BNI People's Business Credit (BNI KUR) is Rp714.744,00.

Keywords: Rice Farming, Microinsurance, Microcredit, Utility Function, Indifference Curve, Budget Line.

1. Introduction

Agriculture is a business that is prone to risk and uncertainty so farmers can face serious difficulties at any time. Especially for farmers in developing countries who are generally small farmers, with an average land area of one to two hectares. Thus, making agricultural land the main source of income. The risks and uncertainties experienced by farmers come from the natural environment, natural disasters, climate, and plant disturbing organisms. These various sources of risk and uncertainty lead to low resilience of farmers (Marr *et al.*, 2016).

To anticipate these risks and uncertainties, farmers can take agricultural insurance or apply for credit. Currently, the government has made innovations to protect farmers from the risk of crop failure or damage in the form of the Rice Farming Business Insurance (AUTP) program. By participating in the Rice Farming Business Insurance (AUTP) program, rice farmers both landowners and cultivators are expected to avoid losses due to damage or crop failure (Nakatsuji, 2004). Even though an agricultural insurance program is available, there are still some obstacles faced by farmers, including the limited amount of collateral and liquidity constraints.

The solution that can be done so that small farmers who have limited collateral constraints can still access loans, namely by combining microinsurance with microcredit. Previous research on this matter has been done. Akotey and Adjasi (2016) state that households using microcredit combined with microinsurance gain significant benefits in terms of improving welfare. Mariyono (2018) say that microcredit has a positive impact both directly and indirectly on rural prosperity. Syll (2019) states that if crop insurance and agricultural loans are combined the demand for crop insurance increases with the profitability of agricultural credit investments, and decreases with the level of collateral required during credit application.

Based on the explanation above, the purpose of this study is to analyze the relationship between demand for insurance and profitability of agricultural credit using the utility function, determine the ordinal comparison between

microinsurance combined with agricultural credit when consumers are required to provide collateral and are not required to provide collateral to access agricultural credit, and apply in a case study of the optimal demand for microinsurance combined with microcredit in rice farming by maximizing utility.

2. Literature Review

Microinsurance

Microinsurance is a means of protecting low-income people from certain risks in exchange for regular premium payments that are commensurate with the likelihood and cost of the relevant risk. The purpose of developing microinsurance is so that people with low incomes have insurance as a risk management tool, namely providing compensation for the risks they face (Adhana and Saxena, 2017).

Microcredit

According to Mariyono (2018), microcredit is a group financial service that specifically targets the poor and marginalized who cannot get access to loans from conventional banking services. Microcredit is usually intended for micro, small, and medium enterprises.

Derivative

According to Verberg et al. (2007), the search for derivatives is called differentiation. In the derivative is known as Leibniz notation, that is if $y = f(x)$, then the derivative notation of f can be expressed as $f'(x)$, $D_x f(x)$ or $\frac{dy}{dx}$. If $z = f(x, y)$, then the partial derivative of f with respect to x is given in equation (1) and the partial derivative of f with respect to y is presented in equation (2).

$$f_x(x, y) = \frac{\partial z}{\partial x} = \frac{\partial f(x, y)}{\partial x} \quad (1)$$

$$f_y(x, y) = \frac{\partial z}{\partial y} = \frac{\partial f(x, y)}{\partial y} \quad (2)$$

where ∂ represents the partial derivative symbol, $\frac{\partial}{\partial x}$, and $\frac{\partial}{\partial y}$ represents the linear operator.

Taylor Series

If $f(x)$ can be derivative up to n times at $x = b$, then $f(x)$ can be expressed as a power series in $(x - b)$ given in equation (3).

$$f(x) = f(b) + \frac{f'(b)}{1!}(x - b) + \frac{f''(b)}{2!}(x - b)^2 + \frac{f'''(b)}{3!}(x - b)^3 + \dots \quad (3)$$

the above series is called the Taylor series with center $x = b$.

Utility Theory and Utility Function

The utility is the level of satisfaction that a person receives after consuming goods. In considering the risks faced by consumers can use the utility function. The utility function is defined as a mathematical formula in determining the utility level for each purchase of a combination of goods. The general form of the utility function can be written as equation (4).

$$U(X) = U(X_1, \dots, X_n) \quad (4)$$

where X represent the index and X_1, \dots, X_n represent the goods consumed by consumers (Pindyck & Rubinfeld, 2013).

Ordinal Approach

Ordinal utility theory is a theory that explains the principles of maximizing the utility obtained by consumers with relatively limited incomes. In the ordinal approach, the utility obtained by consumers after consuming goods cannot be quantified (Sukirno, 2016). The analysis used in the ordinal approach uses indifference curves and budget line (Pindyck & Rubinfeld, 2013).

Indifference Curve

Indifference curve is a curve that represents all possible combinations of two goods that provide the same level of utility for consumers. The characteristics of an indifference curve include having a negative slope, a higher curve position indicating a higher level of utility, between one curve and another never intersecting each other, and the shape of the curve is convex to the point (0,0). The slope of the indifference curve is expressed in the Marginal Rate of Substitution (MRS) given in equation (5).

$$MRS = -\frac{MU_X}{MU_Y} = -\frac{\Delta Y}{\Delta X} \quad (5)$$

where MU_X represents the marginal utility of good X , MU_Y represents the marginal utility of good Y , ΔX represents the change in the quantity of good X , and ΔY represents the change in the quantity of good Y (Pindyck & Rubinfeld, 2013).

Budget Line

The budget line is a line that describes the possible combinations of goods that can be purchased by consumers according to income, assuming the consumer spends all of his income on purchases. The budget line equation is given in equation (6).

$$P_X \cdot X + P_Y \cdot Y = I \quad (6)$$

where P_X represents the price of the product X , P_Y represents the price of the product Y , X represents the quantity of good X , Y represents the quantity of good Y , and I represents the consumers fix income. According to Pindyck and Rubinfeld (2013), the slope of the budget line is expressed in equation (7).

$$\frac{dY}{dX} = -\frac{P_X}{P_Y} \quad (7)$$

Consumer Balance

According to the indifference curve theory, the optimal condition of good X and Y at a given income when the budget line is tangent to one of the indifference curves (Nicholson, 1995). The intersection represents the highest level of utility that consumers can achieve after consuming goods X and Y with a fixed income (Lawson & Manning, 2001). According to Pindyck and Rubinfeld (2013), consumer balance will be obtained at the point where it fulfill equation (8).

$$\frac{MU_X}{MU_Y} = \frac{P_X}{P_Y} \quad (8)$$

3. Materials and Methods

3.1. Materials

The data used is a mathematical model of rice agricultural consumption combined with agricultural credit Syll (2019), the premium price of Rice Farming Business Insurance (AOTP) is Rp36.000,00/Ha/MT, which is obtained from the official website of the Ministry of Agriculture of the Republic of Indonesia (<https://www.pertanian.go.id>), installments of BNI People's Business Credit (BNI KUR) of Rp587.126,00/month obtained from the Cimahi City BNI branch office, income data and consumption options for Rice Farming Business Insurance (AOTP) and BNI Credit People's Business (BNI KUR) rice farmers in Pasirlangu Village and Ngamprah Village, West Bandung Regency obtained through questionnaire.

3.2. Methods

The methods used is utility function analysis and ordinal approach. Utility function analysis is used to determine the relationship between insurance demand and agricultural credit profitability. While the ordinal approach is used to maximize utility in determining the optimal demand for Rice Farming Business Insurance (AOTP) combined with BNI People's Business Credit (BNI KUR) for rice farmers.

4. Results and Discussion

Modification of the Consumption Model of Carter et.al (2014) and Sarris (2002)

The consumption model of Carter et.al (2014) and Sarris (2002) is given in equation (9).

$$c(y_t) = c_t^* + \beta(y_t - y_t^*) \quad (9)$$

where y_t represents income in period t , y_t^* represents fixed income in period t , c_t^* represents fixed consumption in period t , and β represents consumption equipment factor. The next step involves agricultural credit in equation (9) by substituting $\beta(y_t - y_t^*)$ with $(r - i)a_{t-1}$ to obtain equation (10).

$$c(a_{t-1}) = c_t^* + (r - i)a_{t-1} \quad (10)$$

where a_{t-1} represents the return on credit investment in period $t - 1$, r represents the rate of return on agricultural credit, i represents interest, and $(r - i)a_{t-1}$ represents the profit of agricultural credit in period $t - 1$.

Utility Functions

The utility function of rice farming consumption combined with agricultural credit consists of two cases. The first case is when farmers are not required to provide collateral for agricultural credit applications and insurance premiums are not previously financed by agricultural credit. The second case is when farmers are required to provide collateral for agricultural credit applications and insurance premiums are financed by agricultural credit. Determination of the utility function by calculating the consumption model of rice farming combined with agricultural credit in equation (10) with insurance contracts and without insurance contracts in the production period and sales period. The utility functions of the first and second cases are presented in Table 1 and Table 2.

Table 1: First Case Utility Function

	Consumption without an Insurance Contract	Consumption with Insurance Contract
Production Period	$U(c_1^* + (r - i)a_0)$	$U(c_1^* + (r - i)a_0 - B)$
Sales Period	$EU(c_2^* + (r - i)a_1)$	$EU(c_2^* + (r - i)a_1 + z)$
Agricultural Season	$U(c_1^* + (r - i)a_0) + \delta EU(c_2^* + (r - i)a_1)$	$U(c_1^* + (r - i)a_0 - B) + \delta EU(c_2^* + (r - i)a_1 + z)$

Table 2: Second Case Utility Function

	Consumption without an Insurance Contract	Consumption with Insurance Contract
Production Period	$U(c_1^* + (r - i)a_0 - g)$	$U(c_1^* + (r - i)a_0 - (g + (1 + i)B))$
Sales Period	$EU(c_2^* + (r - i)a_1 + g)$	$EU(c_2^* + (r - i)a_1 + g + z)$
Agricultural Season	$U(c_1^* + (r - i)a_0 - g) + \delta EU(c_2^* + (r - i)a_1 + g)$	$U(c_1^* + (r - i)a_0 - (g + (1 + i)B)) + \delta EU(c_2^* + (r - i)a_1 + g + z)$

where c_1^* represents fixed consumption in the production period, c_2^* represents fixed consumption in the sales period, $(r - i)a_0$ represents credit profit for the previous period, $(r - i)a_1$ represents credit profit for the production period, g represents collateral, a_0 represents return on credit investment for the period previously, a_1 represents return on credit investment for the production period, B represents agricultural insurance premiums, iB represents interest on insurance premium payments by agricultural credit, z represents compensation, and δ represents discount.

Analysis of Farmers Willingness to Pay for Insurance

The analysis is carried out by equating the utility function of the rice farming season without an insurance contract and accompanied by an insurance contract in each case based on Table 1 and Table 2. Then simplification is carried out using the Taylor series formula based on equation (3). Then apply the definition of Arrow Pratt risk aversion coefficient $\rho = \frac{-U''^*}{U'^*}$ and assume that $E(z)(r - i) = E(z)(E(r) - i)$. So we get equation (11).

$$B - Ba_0\rho(r - i) + \frac{1}{2}B^2\rho + \delta E(z) + \delta a_1\rho E(z)(r - i) + \frac{1}{2}\delta\rho E(z^2) = 0 \quad (11)$$

where ρ represents the Arrow Pratt risk aversion coefficient, $(r - i)$ represents the profitability of agricultural credit, and $E(z)$ represents the expected value of payments. Equation (11) shows the premium that the farmer must pay in

the first case of the production period so that the utility obtained is the same when the farmer does not register an insurance contract for the rice farming season.

$$B(1+i) - Ba_0\rho(r-i)(1+i) + Bg\rho(1+i) + \frac{1}{2}B^2\rho(1+i)^2 - \delta E(z) + \delta a_1\rho E(z)(r-i) + \frac{1}{2}\delta\rho E(z^2) + \delta\rho gE(z) = 0 \quad (12)$$

Equation (12) shows the premium that farmers must pay in the second case of both production periods so that the utility obtained is the same when farmers do not buy insurance contracts for the rice farming season.

Analysis of The Relationship Between Insurance Demand and Agricultural Credit Profitability

The analysis was carried out in the first case and the second case by considering the amount of agricultural credit in the previous period is the same as the production period ($a_0 = a_1$) and the amount of agricultural credit in the previous period was different from the production period ($a_0 \neq a_1$). In the first case equation (11) is partially derived from the profitability of agricultural credit ($r - i$) using equation (1), so that equation (13).

$$\frac{\partial(B - Ba_0\rho(r-i) + \frac{1}{2}B^2\rho + \delta E(z) + \delta a_1\rho E(z)(r-i) + \frac{1}{2}\delta\rho E(z^2))}{\partial(r-i)} = \rho(\delta a_1 E(z) - Ba_0) \quad (13)$$

If the amount of credit in the previous period is the same as the production period ($a_0 = a_1$), then equation (13) becomes equation (14).

$$\frac{\partial(B - Ba_0\rho(r-i) + \frac{1}{2}B^2\rho + \delta E(z) + \delta a_1\rho E(z)(r-i) + \frac{1}{2}\delta\rho E(z^2))}{\partial(r-i)} = \rho a_1(\delta E(z) - B) \quad (14)$$

Based on equation (14) when the amount of credit in the previous period is equal to the production period ($a_0 = a_1$) the willingness of farmers to pay for Insurance increases with the profitability of agricultural credit if $\delta E(z) \geq B$. Meanwhile, based on equation (13) if the amount of credit in the previous period is different from the production period ($a_0 \neq a_1$) the willingness of farmers to pay insurance increases with the profitability of agricultural credit if $\delta a_1 E(z) \geq Ba_0$.

In the second case, equation (12) is partially derived from the profitability of agricultural credit ($r - i$) by using equation (1) so that equation (15).

$$\frac{\partial(B(1+i) - Ba_0\rho(r-i)(1+i) + Bg\rho(1+i) + \frac{1}{2}B^2\rho(1+i)^2 - \delta E(z) + \delta a_1\rho E(z)(r-i) + \frac{1}{2}\delta\rho E(z^2) + \delta\rho gE(z))}{\partial(r-i)} = \rho(\delta a_1 E(z) - Ba_0(1+i)) \quad (15)$$

If the amount of credit in the previous period is the same as the production period ($a_0 = a_1$), then equation (15) becomes equation (16).

$$\frac{\partial(B(1+i) - Ba_0\rho(r-i)(1+i) + Bg\rho(1+i) + \frac{1}{2}B^2\rho(1+i)^2 - \delta E(z) + \delta a_1\rho E(z)(r-i) + \frac{1}{2}\delta\rho E(z^2) + \delta\rho gE(z))}{\partial(r-i)} = \rho a_1(\delta E(z) - B(1+i)) \quad (16)$$

Based on equation (16) when the amount of credit in the previous period is the same as the production period ($a_0 = a_1$) the willingness of farmers to pay for insurance increases with the profitability of agricultural credit if $\delta E(z) \geq B(1+i)$. Meanwhile, based on equation (15) if the amount of credit in the previous period is different from the production period ($a_0 \neq a_1$) the willingness of farmers to pay for insurance increases with the profitability of agricultural credit if $\delta a_1 E(z) \geq Ba_0(1+i)$.

Ordinal Comparison

The ordinal comparison is determined by comparing the benefits by farmers from insurance contracts and agricultural credit when farmers are required to provide collateral and are not required to provide collateral to access agricultural credit based on the explanation in section 3.4. The benefits obtained by farmers from agricultural

insurance and credit contracts are more profitable when collateral is not requested when accessing agricultural credit and when the amount of credit in the previous period is the same as the production period ($a_0 = a_1$) because farmers get proportional benefits from insurance contracts and agricultural credit on conditions that make it easier for farmers, namely without collateral and without increasing the amount of credit in the production period.

Rice Farming Business Budget Line

The average income of rice farmers in Pasirlangu Village and Ngamprah Village, West Bandung Regency is Rp1.414.023,81/month rounded up to Rp1.414.024,00/month. In this study, P_X stated that the installment of BNI People's Business Credit (BNI KUR)/month is Rp587.126,00, P_Y stated the premium for Rice Farming Business Insurance (AOTP)/month is Rp36.000,00, and I stated the average income rice farmers in Pasirlangu Village and Ngamprah Village, West Bandung Regency is Rp1.414.024,00/month. Furthermore, the equation of the rice farmers budget line is determined by using equation (6) and so that equation (17).

$$587.126X + 36.000Y = 1.414.024 \quad (17)$$

where X represents the number of installments of BNI People's Business Credit (BNI KUR)/month and Y represents the total premium for Rice Farming Business Insurance (AOTP)/month.

While calculating the slope of the budget line using equation (7) the following results are obtained:

$$\begin{aligned} \frac{dY}{dX} &= -\frac{P_X}{P_Y} \\ &= -\frac{587.126}{36.000} \\ &= -16,309 \end{aligned}$$

this means that to increase the consumption of 1 installment of BNI People's Business Credit (BNI KUR), farmers must reduce a total of 16,309 Rice Farming Business Insurance (AOTP) premiums.

Equation (17) is used to determine the combination of Rice Farming Business Insurance (AOTP) premiums and BNI People's Business Credit (BNI KUR) installments that can be reached by farmers according to the available income, the combination of Rice Farming Business Insurance (AOTP) premiums and BNI People's Business Credit (BNI KUR) installments are presented in Table 3.

Table 3: Combination of Rice Farming Business Insurance (AOTP) Premiums and BNI People's Business Credit (BNI KUR) Installments

Installments BNI KUR (X)	Premiums AOTP (Y)	Income (I)
0	39,278	1.414.024
0,5	31,124	1.414.024
1	22,969	1.414.024
1,5	14,815	1.414.024
2	6,660	1.414.024
2,408	0	1.414.024

The Combination of Rice Farming Business Insurance (AOTP) premiums and BNI People's Business Credit (BNI KUR) installments in Table 3 is visualized as a rice farming business budget line with the help of Python software. The rice farming budget line is presented in Figure 1.

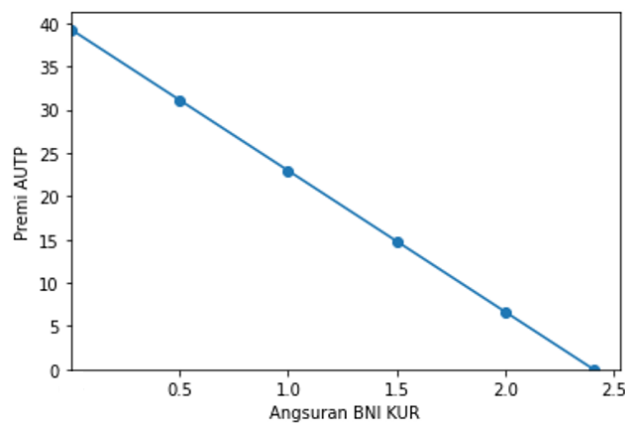


Figure 1: Rice Farming Business Budget Line

Rice Farmer Indifference Curve

Prior to collecting data on rice farmers, several farmers were observed to estimate their average monthly income. Information obtained that farmers have an income of less than Rp1.000.000,00/month, this nominal is used to determine the combination of Rice Farming Business Insurance (AUTP) premiums and BNI People's Business Credit (BNI KUR) that can be reached by farmers. From this combination an indifference curve is formed which is visualized in Figure 2.

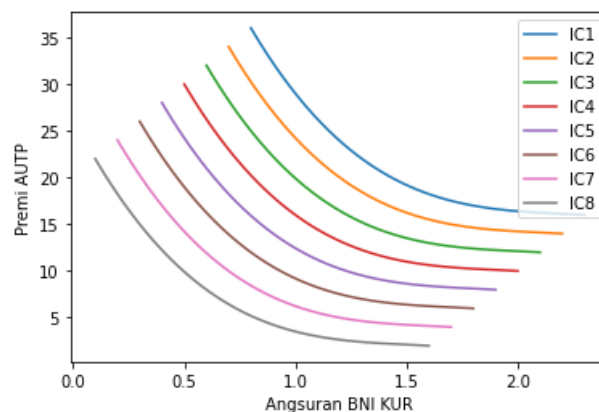


Figure 2: Rice Farmers Indifference Curve

Based on the data obtained from the questionnaire, 3 farmers chose IC1, 2 farmers chose IC2, 1 farmers chose IC3, IC4, IC5, 6 farmers chose IC6, IC7, and 15 farmers chose IC8.

Maximum Utility

The farmers maximum utility point is obtained by combining the rice farming budget line and the indifference curve. The point of maximum utility at the intersection of the rice farming budget line and one of the indifference curves.

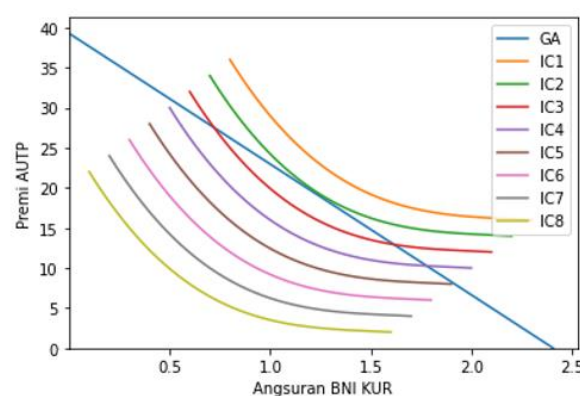


Figure 3: Maximum Utility of Rice Farmers

Based on Figure 3, the point of maximum utility at the intersection of the budget line and IC2. At the point the farmer obtains the maximum utility with the available income. By using equation (8) the maximum utility point of rice farmers is obtained at the coordinates (1,191, 19,854). Furthermore, the coordinates are multiplied by the premium for Rice Farming Business Insurance (AUTP) Rp36.000,00 and the installment of BNI People's Business Credit (BNI KUR) Rp587.126,00. Calculation as follows:

Installment BNI KUR is $X \times P_X = 1,191 \times \text{Rp}587.126,00 = \text{Rp}699.267,07$

Premium AUTP is $Y \times P_Y = 19,854 \times \text{Rp}36.000,00 = \text{Rp}714.744,00$.

So that the optimal demand for Rice Farming Business Insurance (AUTP) combined with the installment of BNI People's Business Credit (BNI KUR) for rice farmers in Pasirlangu Village and Ngamprah Village, West Bandung Regency when the premium Rice Farming Business Insurance (AUTP) is Rp699.267,07 and installment of BNI People's Business Credit (BNI KUR) is Rp714.744,00.

5. Conclusion

From this study, it can be concluded that the demand for insurance and agricultural credit profitability increases when collateral is not requested when applying for agricultural loans. However, when collateral is required to apply for agricultural loans, the demand for insurance decreases and the profitability of agricultural loans increases. An ordinal comparison is obtained that micro insurance combined with agricultural credit is more profitable for farmers when collateral is not requested when applying for agricultural credit and the amount of credit in the previous period is the same as the production period ($a_0 = a_1$). Optimal demand for Rice Farming Business Insurance (AUTP) combined with BNI People's Business Credit (BNI KUR) for rice farmers in Pasirlangu Village and Ngamprah Village, West Bandung Regency when the premium is Rp699.267,07 and installments is Rp714.744,00.

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