

## Willingness to Pay of Fishermen Insurance Using Logistic Regression Model

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### Abstract

*The high risk of losing fishermen's life while at sea is not proportional to their low welfare conditions. Fishermen also cannot meet their daily needs when they are not fishing. Therefore, the guarantee of fishermen's welfare is seen as a solution to this problem, which in the long run is expected to improve the welfare of fishermen. This study aims to analyze the factors that affect Willingness to Pay (WTP) in the fishermen welfare guarantee program. The case study in this research is the people in Ambulu Village, Losari District, Cirebon Regency, West Java, who work as fishermen. The factors analyzed in broad outline include: social factors in the fishermen community, professional factors as fishermen, and economic factors for the fishermen community, which as a whole include 20 independent variables. The analytical method used is a logistic regression model, where the parameter estimation is carried out using the Newton Raphson approach. The results of the analysis show that the factors which significantly influence the WTP in guaranteeing fishermen's welfare are the level of fishermen's education, membership of the local fishermen community, membership of fishermen in Ambulu Village, and knowledge of fisherman insurance. These four factors produce a logistic regression model that is used to predict the probability value of fishermen's WTP. From this model, the lowest WTP probability value is 0.00029 and the highest is 0.96719. Based on the results of this study, it can be used as consideration for the parties involved in the development of a fishermen welfare guarantee program.*

*Keywords:* fishermen, fishermen insurance, Willingness to Pay, Logistic Regression, Newton Raphson

### 1. INTRODUCTION

The role of fishermen is very important for Indonesia's economic growth in the marine and fisheries sectors. However, the very important role of fishermen is also followed by a high risk of losing their lives (Firdaus and Witomo [3]). Fishermens high risk of losing life is inversely proportional to their welfare condition of fishermen in Indonesia, which is still very low, contributing around 25% of the national poverty rate (Anwar and Wahyuni [1]). In

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addition, when fishermen are not going into sea, fishermen will be unable to get income so they will not meet their daily needs. This is one of the main factors that impact to the low welfare condition of fishermen in Indonesia. Therefore, the government, through the Ministry of Maritime and Fisheries Affairs, are striving to improve the fishermen's welfare, one of which through the provision of insurance.

Insurance for fishing communities in Indonesia has existed in terms of life insurance, health insurance and property insurance, but there are lot rooms for improvement so that it may provide compensation or income for fishermen when they are not going into the sea. If this condition meets, there will be a chance for fishermen to meet their family's daily needs and also increasing their welfare condition (Rani [12]).

In Indonesia, insurance has developed a lot in the agricultural and livestock sector, where farmers and ranchers will get compensation for crop failure or the death of their livestock (Otoritas Jasa Keuangan [11]). From this concept, farmers and ranchers will still get income to meet their daily needs regardless of the condition. According to Mumford *et al* [9], there are basic similarities in the actuarial components of agricultural and livestock insurance with fishermen insurance, thus allowing the development of the same concept in fishermen insurance.

Fishermen insurance has developed a lot in other countries, such as China, Japan, Korea and many more, where this development also carries positive growth into their fishermen's welfare condition (Food and Agriculture Organization of United Nations [4]). Several studies have also been carried out as a basis for fishermen insurance development, including Zekri *et al* [15] who examined fishermen's Willingness to Pay in Oman, Han and Jiang [5] who examined fishermen's Willingness to Pay in China then evaluate the government regulations there, Okechukwu [10] who examined the impact of loans on fishermen insurance premiums in Nigeria, Rimawati *et al* [13] conducted an analysis with the Analytic Network Process (ANP) on fishermen clusters in Sukabumi and Pangandaran, as well as other studies that support fishermen insurance development in other countries.

In this research, the fishermen's Willingness to Pay (WTP) will be generated using logistic regression model with parameters estimated by Maximum Likelihood Estimation (MLE) based on Newton Raphson approximation. From the model obtained, the probability value of fishermen's WTP can be measured for the development of fishermen insurance in Indonesia.

## 2. MATERIAL AND METHODOLOGY

In this research, there are some foundations that being used as the material. Those foundations are as explained below

**2.1. Material.** This research uses primary data that is taken from 115 fishermen respondents in Ambulu Village, Losari District, Cirebon, West Java on November 2020. Of the 115 research respondents, it was found that 85 respondents have willingness to pay premiums to participate the fishermen welfare insurance, while 15 others have not. The factors that influence the fishermen's Willingness to Pay (WTP) consist of fishermen's age ( $X_1$ ), marital status ( $X_2$ ), education level ( $X_3$ ), number of family members ( $X_4$ ), experience as fishermen ( $X_5$ ), fishermen's education ( $X_6$ ), how to go to sea ( $X_7$ ), go to sea during bad weather ( $X_8$ ), time to go to sea ( $X_9$ ), duration of fishing ( $X_{10}$ ), membership status of fishing community ( $X_{11}$ ), membership status of community organizations ( $X_{12}$ ), fulfillment of needs ( $X_{13}$ ), ownership of credit ( $X_{14}$ ), ownership of business capital ( $X_{15}$ ), government premium subsidies ( $X_{16}$ ), community membership status ( $X_{17}$ ), knowledge of how insurance works ( $X_{18}$ ), knowledge of fishermen's insurance ( $X_{19}$ ), and insurance interests ( $X_{20}$ ). The value of all independent and dependent variables in this research are binary. Of all the independent variables, multicollinearity test is carried out using the Chi-Square Test (Hadi, [6]) as an assumption of logistic regression model.

The calculating and working process for the multicollinearity test use the SPSS 16.0 software. If there is a multicollinearity symptom, variable selection will be applied from the amount of the Contingency Coefficient for each independent variable and its multicollinear

factor. Furthermore, after qualified the assumption of not containing multicollinearity symptom, the parameters of the independent variables will be estimated using the MLE method with Newton Raphson approximation assisted by Statistical Analysis Software (SAS).

**2.2. Binary Logistic Regression.** According to Harlan [7], binary logistic regression is used to measure the effect of the continuous or categorical independent variable ( $X$ ) on the dependent variable ( $Y$ ) which has a dichotomic or binary values. The general form of logistic regression is:

$$\text{logit}(Y) = \ln O(Y) = \ln \frac{P(Y)}{1 - P(Y)} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p, \quad (1)$$

which can be written in Odds of Y with:

$$O(Y) = \frac{P(Y)}{1 - P(Y)} = e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p}, \quad (2)$$

then, from the equation (2), it can be formed into probabilistic equation in logistic regression, which is:

$$P(Y) = \frac{e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p}}{1 + \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p}, \quad (3)$$

where the equation (3) can be used to calculate the value of a probability in logistic regression model.

**2.3. Parameter Estimation in Logistic Regression.** According to the value of dependent variabel which is dichotomic or binary, it uses Bernoulli Distribution as the probability distribution. It will generate the likelihood function which is the combination of all parameters probability function in model. Therefore, it can be said that the likelihood function for logistic regression is:

$$L(\beta) = \prod_{i=1}^n [P(Y)]^{Y_i} \cdot [1 - P(Y)]^{1 - Y_i}, Y_i = \{0, 1\}, \quad (4)$$

then while equation (3) is substituted into equation (4), it will produce:

$$L(\beta) = \prod_{i=1}^n [e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p}]^{Y_i} \cdot [1 + e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p}], \quad (5)$$

and if the equation (5) is transformed with natural logarithm, it becomes:

$$\ln L(\beta) = \sum_{i=1}^n \left[ Y_i \left\{ \sum_{p=0}^p \beta_p X_{ip} - \ln \left( 1 + e^{\sum_{p=0}^p \beta_p X_{ip}} \right) \right\} \right]. \quad (6)$$

As for  $\beta$  in equation (6) will be estimated with Newton Raphson approximation, because the function is not in linear form and it needs an approximation to estimate the parameters value.

**2.4. Newton Raphson Approximation.** Newton Raphson is a numerical method to count the linear and non-linear equation roots (Saputri [14]). The general equation in Newton Raphson is:

$$\beta^{(a+1)} = \beta^a + [X^T U X]^{-1} [X^T (Y_1 - \pi(X_1))], \quad (7)$$

which  $a$  is the iterations index ( $a = 0, 1, 2, \dots$ ), with:

$$X = \begin{bmatrix} 1 & X_{11} & \dots & X_{1P} \\ 1 & X_{21} & \dots & X_{2P} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & X_{n1} & \dots & X_{nP} \end{bmatrix},$$

$$U = \begin{bmatrix} \pi(X_1)(1 - \pi(X_1)) & 0 & \dots & 0 \\ 0 & \pi(X_2)(1 - \pi(X_2)) & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \pi(X_p)(1 - \pi(X_p)) \end{bmatrix},$$

$$Y_1 - \pi(X_1) = \begin{bmatrix} Y_1 - \pi(X_1) \\ Y_2 - \pi(X_2) \\ \vdots \\ Y_n - \pi(X_n) \end{bmatrix}.$$

Newton Raphson iterated until the requirement of  $\hat{\beta}^{(a+1)} - \hat{\beta}^a < \varepsilon$  is met, where  $\varepsilon$  is the error which commonly valued at  $\frac{1}{10,000}$  or 0.0001.

**2.5. Parameter Signification Test.** After obtaining the value of each parameter in the model, there will be significance tests of these parameters that consisted of an overall significance test and an individual significance test. The overall significance test is the Likelihood Ratio Test and the individual significance test is the Wald Test (Hosmer and Lemeshow [8]). In addition, to determine the quality of the model from the relationship between the independent variables and the dependent variable, there will be a calculation of  $R^2$  ( $R$ -Square).

**Likelihood Ratio Test.** In testing the overall significance test, the formula which will be used is:

$$G = -2 \ln \left[ \frac{\text{likelihood without independent variables}}{\text{likelihood with independent variables}} \right], \quad (8)$$

where the hypothesis used in this test, are  $H_0 : \hat{\beta}_1 = \hat{\beta}_2 = \dots = \hat{\beta}_P = 0$  dan  $H_1$ : There is  $\hat{\beta}_p \neq 0$  for  $p = 1, 2, , P$ . As for criteria that used in this test is rejected  $H_0$  if  $G > \chi^2_{(\alpha, P)}$  and accept  $H_0$  for the opposite condition.

**Wald Test.** In testing the individual test, the formula which will be used is:

$$W_p = \left[ \frac{\hat{\beta}_p}{\text{SE}(\hat{\beta}_p)} \right]^2, \quad (9)$$

with  $\text{SE}(\hat{\beta})_p = (X^T U X)^{-1}$  where  $X$  and  $U$  are matrix such explained in the equation (7). The hypothesis used in this test, are  $H_0 : \hat{\beta} = 0$  and  $H_1 : \hat{\beta}_p \neq 0$  for  $p = 1, 2, , P$ , with the testing criteria is reject  $H_0$  if  $W_p > \chi^2_{(\alpha, 1)}$ , and accept  $H_0$  for the opposite condition.

**$R^2$  (R-Square).** In determine the quality of model, it will be seen from the relation between independent variables and dependent variable, from the value of  $R^2$  in:

$$R^2 = 1 - \exp \left[ - \left( \frac{L}{n} \right)^2 \right], \quad (10)$$

where the higher  $R^2$  and closer to 1, means the relation between independent and dependent variables is strong, so that it can be inferred that the model is better. Otherwise, the lower  $R^2$  and closer to 0, means the relation between independent and dependent variables is weak, so that can be inferred that the model is worse.

### 3. RESULT AND ANALYSIS

Before doing the parameter estimation, multicollinearity test within the independent variables is carried out to get the efficient estimator so the standard error of each parameter is not overheight. Since there is a multicollinearity symptom in the model, variables selection is used base on the value of its Contingency Coefficient (Dillon [2]). It results  $X_6, X_{11}, X_{17}$ , and  $X_{19}$  are not containing multicollinear symptom and will be selected into the model, whereas the rests will not be selected.

**3.1. Parameter Estimation Result.** The parameter estimation is performed by maximizing the equation (6) the use the Newton Raphson Iteration such in equation (7) with steps as explained in part 2.4. The estimation result using MLE based on Newton Raphson Iteration with SAS as given in Table 1.

TABLE 1. Logistic Regression Parameter Estimation

Parameter	Parameter Value	Standard Error	$W_p$	$\chi^2_{(0.05,1)}$	Result
$\hat{\beta}_0$	-8.0636	-	-	-	Significance
$\hat{\beta}_6$	3.4138	1.2979	13.6409	3.8415	Significance
$\hat{\beta}_{11}$	2.7221	0.8998	9.1518	3.8415	Significance
$\hat{\beta}_{17}$	3.2628	1.3565	5.7859	3.8415	Significance
$\hat{\beta}_{19}$	2.0488	0.8867	5.3388	3.8415	Significance

According to Table 1, the Ratio Likelihood test using the equation (8), produce the value of  $G$  which is  $132.0123 - 42.931 = 89.081$  with  $\chi^2_{(0.05,4)} = 9.487$ , so that because  $G > \chi^2_{(0.05,4)}$ , the  $H_0$  is rejected which means there is at least one of the independent variables that give effect to dependent variable. The next one, Wald Test result for each parameter using the equation (9) as can be seen in Table 1, where all the parameters are significance.

After passed the criteria of parameter significance test, either overall test and individual test, it can be generated a logistic regression model from those parameters using MLE based on Newton Raphson approximation as in equation (1), which is:

$$\text{logit}(Y) = \ln O(Y) = -8.0636 + 3.4138X_6 + 2.7221X_{11} + 3.2628X_{17} + 2.0488X_{19},$$

or in probabilistic ratio, as in equation (2), it can be written with:

$$O(Y) = e^{-8.0636+3.4138X_6+2.7221X_{11}+3.2628X_{17}+2.0488X_{19}}, \quad (11)$$

and in probabilistic, as in equation (3), it becomes:

$$P(Y) = \frac{e^{-8.0636+3.4138X_6+2.7221X_{11}+3.2628X_{17}+2.0488X_{19}}}{1 + e^{-8.0636+3.4138X_6+2.7221X_{11}+3.2628X_{17}+2.0488X_{19}}} \quad (12)$$

Next, the model quality can be inferred from  $R^2$  using equation (10), so that the  $R^2$  value for the logistic regression model is 0.9818. This means that the relation between independent and dependent variables are strong, because the value of the  $R^2$  is close to 1, then it can be said that the model has good quality.

**3.2. Analysis.** According to the logistic regression model in equation (11), the portion of each independent variables influence can be found by calculating the exponential value of each parameter which contains in Table 2.

TABLE 2. The Exponential Value of Each Parameter

Parameter	Parameter Value	$\text{Exp}(\hat{\beta}_p)$
$\hat{\beta}_0$	-8.0636	0.0003
$\hat{\beta}_6$	3.4138	30.381
$\hat{\beta}_{11}$	2.7221	15.2122
$\hat{\beta}_{17}$	3.2628	26.1226
$\hat{\beta}_{19}$	2.0488	7.7586

From Table 2, it can be interpreted each independent variable influence on the probability ratio of fishermens WTP. Furthermore, it can be said that  $X_6$  give influence of 30.381 times into the probability ratio,  $X_{11}$  give influence of 15.2122 times into the probability ratio,  $X_{17}$  give influence of 26.1226 times into the probability ratio, and  $X_{19}$  give influence of 7.7586 times into the probability ratio. Moreover, if the four independent variables  $X_6, X_{11}, X_{17}$ , and  $X_{19}$  valued at 0, the WTP probability ratio is 0.0003.

The probability value of WTP can be found using equation (12). The boundary of the probability value as given in Table 3.

TABLE 3. The WTP Probability Value Boundary

Value of Variables				P(Y)
$X_6$	$X_{11}$	$X_{17}$	$X_{19}$	
0	0	0	0	0.00029
1	1	1	1	0.96719

From Table 3, if a fisherman never got fisherman education, non member of fishermen community, not registered in fisherman business card (KUSUKA), and do not know about fishermen insurance, the probability of his willingness to pay in joining the fishermen insurance is very low, which exist at 0.00029. Otherwise, if a fisherman has got fisherman education, member of fishermen community, registered in fisherman business card (KUSUKA), and know about fishermen insurance, the probability of his willingness to pay in joining the fishermen insurance is very high, which exist at 0.96719. It also can be said that from those four factors, the more factors being fulfilled or valued at 1, then the higher probability from fishermens WTP to participate in the fishermen insurance.

#### 4. CONCLUSION

From this research, the logistic regression model can be used to find the probability value of fishermens willingness to pay in joining the fishermen insurance. Factors that highly influence the willingness to pay of fishermen, are fisherman education, membership in community, membership in fisherman business card (KUSUKA), and knowledge about fishermen insurance. The probability value if those four factors are not being fulfilled is very low, which at 0.00029, while if those four factors are being fulfilled, is at 0.96719 which is very high. Therefore, it can be concluded that if there are more actions to follow up the improvement of those four factors, then it will produce the higher probability number of fishermens willingness to pay in joining the fishermen insurance.

#### DAFTAR PUSTAKA

- [1] Anwar, Z. dan Wahyuni, 2019, *Miskin Di Laut Yang Kaya: Nelayan Indonesia dan Kemiskinan*. Sosioreligius, Vol. 1, No. 4, Pages 51-60.
- [2] Dillon, W. R., 1979, *Analyzing Large Multiway Contingency Tables: A Simple Method for Selecting Variables*. *Journal of Marketing*, Volume 43, (Fall 1979), Pages 92-102.
- [3] Firdaus, M., dan Witomo, C.M., 2014, *Analisis Tingkat Kesejahteraan dan Ketimpangan Pendapatan Rumah Tangga Nelayan Pelagis Besar di Sendang Biru, Kabupaten Malang, Jawa Timur*. *Jurnal Sosial Ekonomi Kelautan dan Perikanan*, Volume 9, No. 2, Pages 155-168.
- [4] Fisheries Circular, 2017, *Food and Agriculture Organization (FAO) of the United Nations*. FAO No. 1139.
- [5] Han, H. dan Jiang, Y., 2019, *Systemic Risks of Climate Events and Households Participation in Mariculture Mutual Insurance: A Case Study of Shrimp Producers in Zhejiang Province*. *MDPI : Sustainability*, Volume 11, 1164.
- [6] Hadi, S., 2016, *Statistik*. Cetakan Ketiga. Yogyakarta: Pustaka Pelajar
- [7] Harlan, J., 2018, *Analisis Regresi Logistik*, Cetakan Pertama, Agustus 2018. Depok: Gunadarma.
- [8] Hosmer, D. W. and Lemeshow, 2000, *Applied Logistic Regression*. Second Edition. New York: John Wiley & Sons Inc.
- [9] Mumford, J., Leach, A., Levontin, P., dan Kell, L., 2009, *Insurance Mechanism to Mediate Economic Risks in Marine Insurance*, *ICES Journal of Marine Science*, 66: Pages 950959.
- [10] Okechukwu, 2019, C. *Impact of fishery agricultural loans and co-operators' insurance premium on the economic growth of fishery production sub-sector in Nigeria*. *IOSR Journal of Economics and Finance (IOSR-JEF)*, Volume 10, Pages 60-68.
- [11] Otoritas Jasa Keuangan (OJK), 2019, *Presentasi Laporan Asuransi OJK*. Otoritas Jasa Keuangan Indonesia.
- [12] Rani, 2016, M. *Insurance Protection for Fisherman*. *Jurnal Selat*, Volume 4, No. 1, Pages 1-14.

- [13] Rimawati, T., Kurnia, T., dan Alhifni, A., 2019, Analysis of Micro Insurance Models for Fishermans (Study in Sukabumi and Pangandaran Port). *Jurnal Ekonomi dan Bisnis Islam (JEBIS)*, Volume 5, No. 2, Pages 134-167.
- [14] Saputri, S.U.D., 2012, *Perbandingan Hasil Estimasi Model Regresi Logistik Biner Menggunakan Metode Maximum Likelihood dan Metode Weighted Least Square*. Skripsi tidak diterbitkan. Surabaya: Universitas Airlangga
- [15] Zekri, S., Mbaga, M., dan Boughanmi, H., 2014, Fishermen Willingness to Participate in an Insurance Program in Oman. *Marine Resource Economics*, Volume 23, Pages 379-391.

