BAREKENG: Jurnal Ilmu Matematika dan Terapan
March 2022 Volume 16 Issue 1 Page 181-188
P-ISSN: 1978-7227 E-ISSN: 2615-3017
https://doi.org/10.30598/barekengvol16iss1pp181-188

ANALYSIS OF THE IMPACT OF COVID-19 IN THE SECOND YEAR ON INCOME OF WORKERS IN WEST JAVA WITH MULTINOMIAL LOGISTIC REGRESSION

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Abstract. *The COVID-19 pandemic that hit Indonesia had a huge impact on the economy. The long period of restriction of population mobility impacted the changes of people's income. West Java is the province with the most workers affected by this pandemic. The income of workers in West Java in the first five months of the pandemic decreased by 50.1%. The existence of these problems shows that an analysis of the impact of covid on changes in worker income is very necessary. This study aims to determine the factors that have a significant effect on changes in workers' income in West Java. Based on the results of the multinomial logistic model suitability test, it was found that there was no difference in the model between the observed results and the predicted results for male workers, therefore the model could be used. In the second year of the covid pandemic, the opportunity for a person's income to decrease in West Java is still very high, at 0.9891. The factors with the highest opportunities that affect income changes in the reduced category are self-employed employment status, changes in work hours, the implementations of WFH, and workers working at terminal/station/airport locations.*

Keywords: *Covid-19, multinomial logistics, income*

Article info:

Submitted: 30th December 2021 *Accepted: 10th February 2022*

How to cite this article:
A. Andriyati, E. Rohaeti and I. Kamila, "ANALYSIS OF THE IMPACT OF COVID IN THE SECOND YEAR ON REVENUE OF WORKERS IN WEST JAVA WITH MULTINOMIAL LOGISTIC REGRESSION", *BAREKENG: J. Il. Mat. & Ter.*, vol. 16, no. 1, pp. 181-188, Mar, 2022.

1. INTRODUCTION

The first case of Covid-19 in Indonesia was confirmed in Depok in March 2020. Since the confirmation of the first case, the government has made various efforts to control the spread of Covid. One of the efforts made is to implement a large-scale social restriction (PSBB) policy in several provinces with high community mobilities. West Java is one of those that implemented the policy in April 2020 [1]. The mobility restriction policy continued to be extended following the peak of the spike in the wave of one Covid case that occurred in January 2021 and the peak of the second surge in July 2021. The lengthy period of restriction on population mobility has an impact on changes in the community's economy.

West Java is the province with the most workers affected by the COVID-19 impact. According to the survey, around 82.29% of Large Enterprises (UMB) and 84.2% of Small Enterprises (UMK) in Indonesia experienced a decline in income [2]. The decrease in business income affected in the decrease in workers' income. The income of workers in West Java in the first five months of the pandemic decreased by 50.1% [3]. The results of the labor force survey in February 2021 showed as many as 3.37 million people in West Java experienced a reduction in working hours. Changes in income will have an impact on people's purchasing power and will ultimately affect national economic growth. The existence of these problems shows that an analysis of the effect of Covid in changes in worker income is indispensable.

Changes in people's income that occur have three categories, as follows increased income, decreased income and no changes. Changes in income are influenced by gender, employment status, working hours, internet usage at work, the implementation of WFH, the location of the place of work to changes in income [3]. The model used is multinomial logistic regression. The multinomial logistic regression model in generally effective where the response variable is composed of more than two categories [4, 5]. Multinomial regression is appropriate to be used to analyze the relationship between multinomial response variables and predictor variables with nominal and ordinal scales [6, 7]. However, in the resulting model [3] there are still differences between the predicted and observed results. The discrepancy of this model is probably due to the imbalance in the number of predictor variables and the amount of data used to model changes in worker income in West Java. In this study, the sample size was adjusted using the latest data, namely the Sakernas data for February 2021.

2. RESEARCH METHODS

The data used in this study were sourced from the labor force survey (Sakernas) of West Java province in February 2021. The criteria for the data taken as a sample are working status and aged between 15 to 65 years. The number of samples that meet the criteria is 4801 people. The variables used in this study are:

1. The response variable Y (change in income) is nominally scaled which consists of three categories, as follows increased income, decreased income and no changes.
2. The nominal scale predictor variable X consists of:
   a. *Gende*r (X_1) with two categories: male and female
   b. Employment status (X_2) with four categories, such as: self-employed, laborers/employees, free agricultural workers, and non-agricultural workers.
   c. Changes in work hours (X_3) with 3 categories, such as: increased working hours, reduced working hours, and no changes.
   d. Internet usage at work (X_4) with two categories: yes and no
   e. WFH implementation (X_5) with two categories: yes and no
   f. Work Location (X_6) with four categories: house, market, roadside, cinema, mall/shop, terminal/station/airport, and other locations

The analytical steps in this study are:

1. Describe the characteristics of the workforce in West Java using descriptive statistics.
2. Conducted an independence test using the Chi-Square test to see the correlation between all predictor variables and the response variable [8]. The hypothesis on the independence test:
   H_0 : The response variables is independent of the predictor variable
   H_1 : The response variable is not independent of the predictor variable
   Chi-Square test statistics are as follows:

$$\chi^2 = \sum_{i=1}^{n} \frac{(o_{ij}-e_{ij})^2}{e_{ij}} \quad (1)$$

o_{ij} = Observation value in row -i column -j
e_{ij} = Expected value in row -i column -j
Rejection area: rejectH_0, if $X^2 > X^2_{a,(i-1)(j-1)}$

3. Conduct simultaneous tests using the *Likelihood Ratio* test (G^2) [7, 9, 10].

$$G^2 = -2 \ln \left[\frac{\left(\frac{n1}{n}\right)^{n1} \left(\frac{n2}{n}\right)^{n2} \left(\frac{n3}{n}\right)^{n3}}{\prod_{j=1}^{b} \pi_1(x)^{y1j} \pi_2(x)^{y2j} \pi_3(x)^{y3j}} \right] \quad (2)$$

4. Conduct a partial test to determine the predictor variables that affect the response variable singly by using the Wald test [11]:

$$W^2 = \frac{\hat{\beta}_j^{\,2}}{\widehat{SE}(\hat{\beta}_j^{\,2})} \quad (3)$$

$\widehat{SE}(\hat{\beta}_j^{\,2})$ = standard error coefficient
$\hat{\beta}_j^{\,2}$ = coefficient value and predictor variable W^2

5. Form a logit model for three response categories [12]:

$$\pi_1(x) = P(y = 1|x) = \frac{e^{P_{1(x)}}}{1+e^{P_{1(x)}}+e^{P_{2(x)}}} \quad (4)$$

$$\pi_2(x) = P(y = 2|x) = \frac{e^{P_{2(x)}}}{1+e^{P_{1(x)}}+e^{P_{2(x)}}} \quad (5)$$

$$\pi_3(x) = P(y = 3|x) = \frac{1}{1+e^{P_{1(x)}}+e^{P_{2(x)}}} \quad (6)$$

With the cumulative logit model:

$$Logit\ P(Y \leq j|x_i) = \left(log \left(\frac{P(Y_i \leq j||x_i)}{P(Y_i > j|x_i)} \right) \right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots + \beta_6 X_6 \quad (7)$$

6. Conduct the suitability test of the model using the *Goodness of Fit* test with the following equation [13]:

$$\hat{C} = \sum_{i=1}^{n} \frac{(O_i - n_i \hat{\pi}_i)^2}{n_i \hat{\pi}_i (1-\hat{\pi}_i)} \quad (8)$$

O_i = Observation in the group - i
$\hat{\pi}_i$ = Probability in the group - i
n_i = The number of observations in the group - i

7. Interpretation of model using the odds ratio.
The odds ratio (OR) was defined as the change in the odds of membership in the target group for a one-unit increase in the predictor [14]. It is assumed that the response variable with $Y = 0$ is the reference response variable. Odds the ratio for $Y = i$ with $Y = 0$ on the value of the variable $x = a$ with $x = b$ [15] is as follows:

$$OR = \frac{P(Y \geq j|x = 1)/P(Y < j|x = 1)}{P(Y \geq j|x = 0)/P(Y < j|x = 0)} \quad (9)$$

The relationship between the odds ratio to the parameter model (β) is $OR = e^{\hat{\beta}} = \exp(\hat{\beta})$.

3. RESULTS AND DISCUSSION

3.1. Characteristics of the workforce of the province of west java

Characteristics of the workforce with working status in the February 2021 labor force survey as much as 40.8% there was a decrease in income. It showed that in the second year of the Covid-19 outbreak, it still has affected the decline in workers' income. The percentages for each category of predictor variables could be seen in Table 1.

Table 1. Percentage of Each Category on Response Variable and Predictor Variable

Variable	Category	N	%
Income Change (**y**)	Increased Income	247	5.1%
	Decreased Income	1957	40.8%
	No change	2597	54.1%
Gender (x_1)	Male	1278	26.6%
	Female	2674	55.7%
Employment status (x_2)	Entrepreneur	378	7.9%
	Laborer/employees	471	9.8%
	Free agriculture workers	66	1.4%
	Non-agriculture workers	1136	23.7%
Changes in work hours(x_3)	Yes, working hours increase	3599	75.0%
	Yes, working hours decrease	2286	47.6%
Internet usage at work(x_4)	No change	2515	52.4%
	Yes	570	11.9%
	No	4231	88.1%
WFH implementation (x_5)	Yes	659	13.7%
	No	150	3.1%
Work location(x_6)	Home	9	0.2%
	Market	176	3.7%
	Cinema	32	0.7%
	Mall/Shop	209	4.4%
	Terminal/Station/Airport	3566	74.3%
	Sideways	3235	67.4%
	Other	1566	32.6%
Total		**4801**	**100.0%**

3.2. Independence Test

The independence test was conducted to determine whether or not there was a relationship between the income change variable and the variables thought to have an effect, including gender, employment status, changes in work hours, internet usage at work, WFH implementation, and work location. The independence test results are shown in Table 2.

Table 2. Independence Test Result

No	Variable	db	χ^2	$\chi^2_{\alpha=0,05}$	P_{value}	Result
1	*Gender*(x_1)	2	12,451	5,991	0,002	Reject H_0
2	Employment Status (x_2)	6	532,214	12,591	0,000	Reject H_0
3	Changes in work hours (x_3)	4	637,619	9,487	0,000	Reject H_0
4	Internet usage at work (x_4)	2	39,786	5,991	0,000	Reject H_0
5	WFH Implementation (x_5)	2	33,507	5,991	0,000	Reject H_0
6	Work location (x_6)	12	242,781	21,026	0,000	Reject H_0

The result of the independence test in Table. 2 showed that the value of χ^2 on each predictor variable (x) is more valuable $\chi^2_{\alpha=0,05}$. It showed that the predictor variable (x) correlates with changes in income (y).

3.3. Modeling the Impact of Covid-19 in the Second Year on Changes in Revenue with Complete Predictor Variable

In this section, the estimation of the multinomial logistic regression model includes all predictor variables, namely *Gender* (x_1), employment status (x_2), changes in work hours (x_3), internet usage at work (x_4), WFH implementation (x_5), and work location (x_6). Parameter estimation using *method maximum likelihood* (MLE). The results of the *likelihood ratio test* produce a value of $G^2 = 53{,}361$ with P_{value}=0,000 as shown in Table 3.

Table 3. *Likelihood Ratio* Test Result

Model	G^2	Db	$\chi^2_{\alpha=0,05}$	P_{value}	Result
Final	838,712	28	16,928	0,000	Reject H_0

The results of the *Likelihood* Ratio test show that at the 95% confidence interval there is at least one predictor variable that simultaneously has a significant effect on changes in income. The resulting logit models are as follows:

$$P_{1(x)} = -2{,}853 + 2{,}346\, X_3(1) - 0{,}7000 X_5(1) \quad (10)$$

$$P_{2(x)} = -0{,}684 + 0{,}227 X_1(1) + 0{,}779 X_2(1) - 0{,}809 X_2(2) + 1{,}062 X_3(1) + 2{,}109 X_3(2) - 0{,}559 X_5(1) + 0{,}848 X_6(2) + 0{,}619 X_6(4) + 1{,}254 X_6(5) + 0{,}825 X_6(6) \quad (11)$$

The logit function $P_{1(x)}$ is the logit model of increasing income and $P_{2(x)}$ is the logit model of decreasing income.

Table 4. The goodness of fit test Model

	Uji *Likelihood Ratio*	
	Chi-Square	P_{value}
Pearson	478,804	0,000

Table 4 is the result of goodness of fit model test using the *Pearson* value. The *Pearson* value = 478.804 with a *P-value* = 0.000 which is smaller than α=0,05 which means Reject H_0. These results indicated that there is a difference between the results of the observations and the predictions of the model.

The logit model that includes all predictor variables results in an unsuitable model. Based on the model equation (10) shows the *gender* variable did not contribute to the model. While the equation model (11) *gender* variable with male category contributed to the model.

3.4. Modeling the Impact of Covid in the Second Year on Changes in the Income of Male Workers.

The multinomial logistic model in this section is taken from a sample of only male workers, which is 3.235 samples. It is done based on the consideration of the results of the model in sub-chapter 3.3. Based on the results of simultaneous testing with the *likelihood ratio* test, it produces a value of $G^2 = 53{,}361$ with a P_{value}=0,000 as shown in Table 5.

Table 5. *Likelihood Ratio* Test Result

Model	G^2	**Db**	$\chi^2_{\alpha=0,05}$	P_{value}	**Result**
Final	468,965	26	15,379	0,000	Reject H_0

The simultaneous test result showed that at the 95% confidence interval, there is at least one predictor variable that simultaneously has a significant effect on changes in income. Testing continued on the partial test using the Wald test. The partial test was conducted to examine the significance of the coefficient β partially. The results of the previous simultaneous test explained that all predictor variables affected on the response variable. In the partial test, the effect of each predictor variable on the response variable will be seen.

Table 6. Partial Test

No	**Variabel**	**Db**	χ^2	$\chi^2_{\alpha=0,05}$	P_{value}	**Results**
1	Employment status (x_2)	6	232,484	12,591	0,000	Reject H_0
2	Changes in work hours (x_3)	4	486,658	9,487	0,000	Reject H_0
3	Internet usage at work (x_4)	2	3,799	5,991	0,150	Accept H_0
4	WFH implementation (x_5)	2	21,247	5,991	0,000	Reject H_0
5	Work location (x_6)	12	54,576	21,026	0,000	Reject H_0

Based on Table 6, the partial test showed that the value of χ^2 on the variable of employment status (x_2), changes in work hours (x_3), WFH implementation (x_5) and work location (x_6) is greater than $\chi^2_{\alpha=0,05}$ or which has a P_{value} of less than α=0.05, while the Internet usage at work (x_4) has a P_{value} of more than α=0.05. It showed that there are four out of five independent variables that statistically have a

significant effect on the response variable, as follows the change in employment status(x_2), changes in work hours(x_3), WFH implementation(x_5), and work location(x_6).

Parameters forming the logit function with no changes in income for comparison are presented in Table 7 and Table 8.

Table 7. Parameter Estimation and Odds Ratio Partial Testing Logit Model 1

Logit	Predictor Variable	B	*Wald*	P_{value}	*Odds Ratio*
1	Constant	-2,972	88,850	0,000	
	Employment Status [1]	0,101	0,062	0,803	1,107
	Employment Status [2]	**0,687**	**4,195**	**0,041**	**1,988**
	Employment Status [3]	-0,043	0,007	0,931	0,958
	Change in work hours [1]	**1,968**	**19,834**	**0,000**	**7,157**
	Change in work hours [2]	0,118	0,181	0,671	1,125
	Internet usage at work [1]	0,033	0,032	0,858	1,034
	WFH Implementation [1]	-0,556	3,279	0,070	0,574
	Work location [1]	0,563	2,488	0,115	1,756
	Work location [2]	0,422	0,595	0,440	1,525
	Work location [3]	0,372	0	0	1,450
	Work location [4]	0,073	0,023	0,880	1,076
	Work location [5]	0,252	0,057	0,812	1,287
	Work location [6]	0,445	0,964	0,326	1,560

The logit model 1 is an income change model with increasing categories, which can be written with the following logit function:

$$P_{1(x)} = -2{,}972 + 0{,}687X_2(2) + 1{,}968X_3(1) \quad (12)$$

Table 8. Parameter Estimation and Odds Ratio Partial Testing Logit Model 2

Logit	Predictor Variable	B	*Wald*	P_{value}	*Odds Ratio*
2	Constant	-0,395	12,527	0,000	
	Employment Status [1]	**0,670**	**22,367**	**0,000**	**1,953**
	Employment Status [2]	**-0,881**	**44,433**	**0,000**	**0,414**
	Employment Status [3]	**-0,399**	**4,794**	**0,029**	**0,671**
	Change in Work Hours [1]	**0,985**	**6,487**	**0,011**	**2,678**
	Change in Work Hours [2]	**2,144**	**375,175**	**0,000**	**8,534**
	Internet Usage at Work [1]	-0,178	3,541	0,060	0,837
	WFH Implementation [1]	**-0,737**	**18,892**	**0,000**	**0,478**
	Work Location [1]	0,093	0,303	0,582	1,097
	Work Location [2]	**0,846**	**13,181**	**0,000**	**2,331**
	Work Location [3]	19,172	0,000	0,997	211926091,731
	Work Location [4]	**0,787**	**11,707**	**0,001**	**2,198**
	Work Location [5]	**1,212**	**7,029**	**0,008**	**3,359**
	Work Location [6]	**0,827**	**18,708**	**0,000**	**2,286**

The logit model 2 is an income change model with decreased categories, which can be written with the following logit function:

$$P_{2(x)} = -0{,}395 + 0{,}670X_2(1) - 0{,}881X_2(2) - 0{,}399X_2(3) + 0{,}985X_3(1) + 2{,}144X_3(2) - 0{,}737X_5(1) + 0{,}846X_6(2) + 0{,}787X_6(4) + 1{,}212X_6(5) + 0{,}827X_6(6) \quad (13)$$

Based on the two logit models, the probability function of the type of income change for each category is obtained as follows:

$$\pi_1(x) = P(y = 1|x) = \frac{e^{P_{1(x)}}}{1 + e^{P_{1(x)}} + e^{P_{2(x)}}} = \frac{e^{(-0{,}299)}}{1 + e^{(-0{,}299)} + e^{(5{,}059)}} = 0{,}0046$$

$$\pi_2(x) = P(y = 2|x) = \frac{e^{P_{2(x)}}}{1 + e^{P_{1(x)}} + e^{P_{2(x)}}} = \frac{e^{(5,059)}}{1 + e^{(-0,299)} + e^{(5,059)}} = 0,9891$$

$$\pi_3(x) = P(y = 3|x) = \frac{1}{1 + e^{P_{1(x)}} + e^{P_{2(x)}}} = \frac{1}{1 + e^{(-0,299)} + e^{(5,059)}} = 0,0063$$

Description:
$\pi_1(x)$= probability function for increased income category
$\pi_2(x)$= probability function for decreased income category
$\pi_3(x)$= probability function for no changes income category

Based on the result of the goodness of fit test model in Table 9, it showed that the *Pearson* =225,871 with a *P-value* =0,071 which is greater than α=0,05 which means Accept H_0. These results indicate that there was no difference between the results of the observations and the predictions of the model.

Table 9. The goodness of fit test Model

	***Likelihood Ratio* Test**	
	Chi-Square	P_{value}
Pearson	225,871	0,071

3.5. Interpretation Odds ratio

Based on the analysis that has been carried out, it is obtained that the probability function for each category of response variables is $\pi_1(x) = 0,0046$, $\pi_2(x) = 0,9891$ and $\pi_3(x) = 0,0063$ it means that the income opportunity of a male worker decreased the highest during the pandemic, which is 0.9891. Meanwhile, the income opportunity to increase by 0.0046 and the opportunity for no change in income during the pandemic is 0.0063.

Based on Table 8, in variable x_2 or classification of employment status with the category of non-agricultural workers as a control, it showed that self-employed workers tend risk of income decline 1.953 greater than no change in income. Compared to no change in revenue, and the status of non-agricultural work tended to decrease the risk of income 0.671 greater than no change in income.

In the variable x_3 or the classification of change in work hours with the category of no change in working hours as a control, it showed that the increased hours' category has a risk tendency of income decline 2,678 greater than no change in income, the reduced hours category has a risk tendency of incone decline 8,534 greater than no change income changes.

In variable x_5 or the implementation of WFH with the category not as a control, it showed that the category that applies WFH tended to risk a decrease in income of 0.478 greater than there is no change in income.

In variable x_6 or work location as a control, indicated the market location category has a risk tendency of income decline 2,331 greater than no change in income, mall/shopping location category has a risk tendency of income decline 2,198 greater than no change in income, the category of terminal/station/airport location has a tendency of income decline risk of 3,359 greater than no change in income, the category of roadside location has a tendency of risk of income decline 2,286 greater than no change in income.

4. CONCLUSION

In the second year of the covid pandemic, the opportunity for a person's income to decrease in West Java is still very high, at 0.9891. The factors with the highest opportunities that affected on the income change category are reduced. They are self-employed status, change in work hours, the implementation of WFH, and workers working at terminal/station/airport locations.

AKNOWLEDGEMENT

This research is internal grant research from Pakuan University with an applied scheme. This research was funded by the Pakuan Siliwangi Foundation with the funding year of 2021.

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