Multiple Linear Regression on Personal Loan Applications and Approvals

Lee Jin Yun, Nur Arina Bazilah Kamisan[*]
Department of Mathematics, Faculty of Science, UTM, Skudai, Johor Bahru, Malaysia
*Corresponding author: nurarinabazilah@utm.my

Abstract
The objective of this study is to investigate the formation of multiple linear regression (MLR) in modelling the relationship between personal loan applications and approvals and factors such as bank interest, consumer price index (CPI), employment and unemployment status before and during the COVID-19 pandemic. The data used is from the 1st of January 2018 to the 30th of June 2022 for this study. Descriptive statistics are used to provide an overview of each variable. The outcome of regression analysis is used to fit models and test statistical significance. To understand the trend, the BNM personal loan application status was investigated based on the period and festival celebrations. It has been discovered that unemployment status has a moderately significant impact and bank interest has a weakly significant impact on BNM personal loan applications in area rarely affected by the COVID-19 status. Furthermore, it has been discovered that employment, and CPI have a weakly significant impact on BNM personal loan approvals.

Keywords: Personal loan; COVID-19 pandemic; Multiple Linear Regression (MLR)

1. Introduction

The ratio of household debt to disposable income in Malaysia is 140.4%, compared to 105.3% in Singapore, 123.3% in the United States, and 52.7% in Thailand, ranking Malaysia as one of the highest in the world. It implies that households in Malaysia take out loans that are, on average, 1.4% of their annual income (Ismail et al., 2018). Food shortages raised inflation in early 2020. The intermittent production and consumption in a few industries caused a temporary bottleneck in the otherwise seamless supply chain management, causing disruptive innovation in supply chain management (Oindrila Chakraborty, 2022). Pandemic containment forced people to save and invest in alternative incomes (Oindrila Chakraborty, 2022).

"Buy now, pay later" encourages Malaysian Generation Y (Gen Y) to overuse credit cards. (Zainudin et al., 2019). Credit card knowledge and self-efficacy are negatively associated with Gen Y credit card misuse in Malaysia, where credit card attitudes, materialism, and social norms are positively correlated with the dependent variable (Zainudin et al., 2019). This paper proposes a collateral-light peer-to-peer personal lending platform. Borrowers' trustworthiness is a predictor of on-time payments (Uriawan et al., 2021). Reputation and relationships determine borrower reliability (Uriawan et al., 2021). The Blockchain Decentralized Application lending platform (DApp) used and smart contracts are used to bind borrowers and lenders/investors (Uriawan et al., 2021). Banks should diversify into noninterest revenue to reduce revenue variability during the COVID-19 pandemic. Performance is positively correlated with noninterest income, but risk is negatively correlated (Li et al., 2021).

The COVID-19 pandemic has hampered banks' ability to meet credit demand and provide liquidity and funding. Global lockdowns and border restrictions have reduced pandemic health expenses and

ensured public safety (Najaf et al., 2022). This study examined the price of goods and services in all sub-sector categories, focusing on necessity goods needed by all consumers. Prices declined throughout the pandemic, with food category CPI increasing and health and education showing similar trends(Kamarudin et al., 2021). Consumer durable goods sales increased during the COVID-19 pandemic due to consumer choices and disposable incomes, but these factors will fade as public health concerns are mitigated and the US economy reopens (Tauber & Van Zandweghe, 2021).

COVID has caused loan delinquency due to high interest rates and business failure, so banks may no longer be more relevant than their credit culture and lending variables as an exposure to priority sector lending (Kumar Tiwari & Bapat, 2020). To aid medium-to-small firms, special credit lines, lower interest rates on loans, deferred repayments, and the development of long-term credit systems are required (Desheng Dash Wu, 2020). Rising oil prices and confirmed new cases have had a positive impact on the Saudi banking index, despite a lockout and interest rate cut (Assous & Al-Najjar, 2021).

Almost 70% of B40 respondents have lost jobs or income (Thinagar et al., 2021). Worse, only 5.6% save for more than six months (Thinagar et al., 2021). Extend consumer credit agreements for the "moratorium" period and several months after, or agree on a compromise reduction in obligations, to mitigate costs for creditors due to the pandemic (Alderman et al., 2020). This approach ensures a fair balance of rights and obligations and helps borrowers adapt to new circumstances while increasing repayment likelihood (Alderman et al., 2020).

The main objectives of the research are is to examine the effect of bank interest, employment status and consumer price index on the chance of getting approval and attraction of people apply personal loan Bank Negara Malaysia before and during COVID-19 pandemic using correlation method and multiple linear regression model.

2. Materials and methods

A. Multiple Linear regression

Multiple regression analysis can be looked upon as an extension of straight-line regression analysis which involves only one independent variable, to the situation in which more than one independent variable must be considered (David, 2014).

The general multiple regression model can be represented by the following equation:

$$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \ldots + \beta_n X_n + \varepsilon_i \tag{1}$$

where
$X_1 \ to \ X_n$ are independent variables
$\beta_0, \beta_1, \beta_2, \ldots\ldots, \beta_n$ are regression coefficients
y is the predicted value of the dependent variable
ε is the is the model's random error (residual) term (how much variation there is in predicted y)

The model takes from

$$y = x_i^{\mathrm{T}} \beta + \varepsilon_i \tag{2}$$

where $^{\mathrm{T}}$ denotes the transpose, so that $x_i^{\mathrm{T}} \beta$ is the inner product between vectors x_i^{T} and β. Often these n equations are stacked together and written in matrix notation as

$$y = X\beta + \varepsilon \tag{3}$$

where

$$y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} \tag{4}$$

$$X = \begin{bmatrix} x_1^{\mathrm{T}} \\ x_2^{\mathrm{T}} \\ \vdots \\ x_n^{\mathrm{T}} \end{bmatrix} = \begin{bmatrix} 1 & x_{11} & \cdots & x_{1p} \\ 1 & x_{21} & \cdots & x_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_{n1} & \cdots & x_{np} \end{bmatrix} \tag{5}$$

$$\beta = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \beta_2 \\ \vdots \\ \beta_p \end{bmatrix} \tag{6}$$

$$\varepsilon = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{bmatrix} \tag{7}$$

The p-values help determine whether the associations observed in your sample are present in the larger population. To apply regression analysis, a model must be fitted and validated. Examine then the regression coefficients and p-values using. Low p-values indicate statistical significance for the independent variable (typically 0.05). The coefficients represent the average change in the dependent variable when the independent variable (IV) is altered by one unit, while the other IVs remain unchanged.

Correlation Coefficient
Correlation coefficient provides a measure of how two random variables are linearly associated in a sample and has properties closely related to those of straight-line regression.
Sample correlation coefficient,

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{(n\sum x^2 - (\sum x)^2)(n\sum y^2 - (\sum y)^2}} \tag{8}$$

Least-square estimate of the slope of fitted regression line,

$$r = \frac{Sx}{Sy} \beta 1 \tag{9}$$

The relationship becomes more positive as r becomes more positive. This implies that, when r is close to 1, a person with a high value for one variable will likely have a high value for the other variable, and a person with a low value for one variable will likely have a low value for the other variable.

The squared correlation coefficient r^2 measures the strength of the linear relationship between the dependent variable Y and the independent variable X. The closer r^2 is to 1, the stronger the linear relationship; the closer r^2 is to 0, the weaker the linear relationship.

B. The ANOVA Table

To summarize the results of a multiple regression analysis, the analysis of variance (ANOVA) technique is often employed. The specific form of an ANOVA table may differ, however, depending on how the contributions of the independent variables are to be regarded (individually or collectively).

$$\text{Correlation coefficient, } r^2 = \frac{SSY - SSE}{SSY} \tag{10}$$

Regression sum of squares,

$$(SSY - SSE) = \sum_{i=1}^{\infty}(\hat{Y}i - Y)^2 \tag{11}$$

Total unexplained variation = Variation due to regression + Residual variation after regression

$$\sum_{i=1}^{\infty}(Yi - Y)^2 = \sum_{i=1}^{\infty}(\hat{Y}i - Y)^2 + \sum_{i=1}^{\infty}(Y_i - \hat{Y}i)^2 \tag{12}$$

Total sum of squares = Regression sum of squares + Residual sum of squares

The test is used to check if there is a linear relationship exists between the dependence variable and at least one of the predictor variables. The hypotheses showed as below:

$$H_0 = \beta_0 = \beta_1 = \cdots = \beta_n = 0$$

$$H_1 = \beta_k \neq 0 \; for \; at \; least \; one \; k$$

Source	Degree of Freedom, DF	Sum of Squares, SS	Mean Square, MS	F value
Model (Regression)	k	$SSY - SSE$	$\dfrac{SS\ Regression}{DF\ Regression}$	$\dfrac{MS\ Regression}{MS\ Resudual}$
Error (Residual)	$n - k - 1$	SSE	$\dfrac{SSE}{DF\ Residual}$	
Corrected Total	$n - 1$	SSY		

The H_0 will be rejected if the calculated F value is bigger than $F_{\alpha,k,(n-(k+1))}$. Rejection of H_0 implies that the regression coefficient differs from zero. That is at least one predictor variable is significant. The significance F value showed in the ANOVA table can also compare with the significance level, α value. If the significance value F is smaller than α, then the null hypothesis can be rejected.

C. T-test

When employing a multiple linear regression model to ascertain whether or not a linear relationship exists between the response and predictor variables, the t-test is utilized to determine the statistical significance of the various regression coefficients. The hypothesis statements to test the significance of a particular regression coefficient, β_p

$$H_0 = \beta_p = 0$$

$$H_1 = \beta_p \neq 0$$

The test statistic for this test is based on t distribution:

$$T = \frac{\hat{\beta}_p}{S_{\hat{\beta}_p}} \tag{13}$$

where $\hat{B}_p$ is the corresponding estimated coefficient and $S_{\hat{\beta}_p}$ is the estimate of the standard error, both are produced by standard regression programs.

H_0 will be rejected if the t-test lies outside the acceptance region, $-t_{\frac{\alpha}{2},n-2} < T_{test} < t_{\frac{\alpha}{2},n-2}$. Rejection H_0 implies that the β_p is significant to the model. Besides, we can also draw the conclusion from p-value. If the p-value is smaller than the significance level, $\alpha = 0.05$, the null hypothesis is rejected. Hence, we have sufficient evidence to conclude that the variable is significantly contribute to the model.

3. Results and discussion

The personal loan data consist of number of applications and number of approvals from BNM as the dependent variable and 5 independent variables.

Labels	Definitions
Response Variable	
Y_1	Personal loan approvals
Y_2	Personal loan applications
Continuous Explanatory Variables	
Interest, X_1	BNM personal loan interest
Employ, X_2	Monthly record: Malaysians get employment
Unemploy, X_3	Monthly record: Malaysian loss of job or retirement
CPI, X_4	Monthly record: Consumer Price Index
Covid, X_5	Monthly new confirmed cases of COVID-19 in Malaysia

A. COVID-19 Cases

The summary below showed that the total monthly Covid-19 cases in Malaysia was 5043957 cases withthe highest record of 763289 cases and the lowest record of 337. The average of the monthly Covid-19 cases is 136323.162.
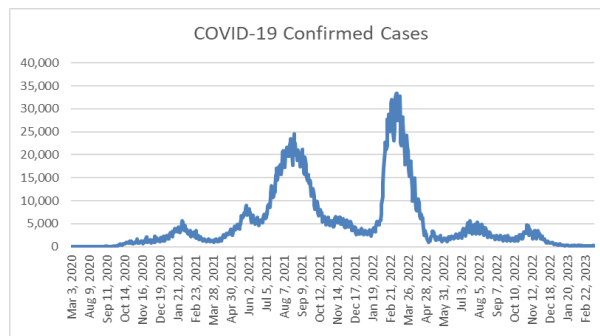
Figure 1 COVID-19 confirmed cases

Table 1 Descriptive statistic of COVID-19 status.

Monthly Covid-19 data from March 2020 to March 2023	
Mean	136323.1622
Standard Error	31271.0331
Median	62085
Mode	-
Standard Deviation	190214.2686
Sample Variance	3.62E+10
Kurtosis	3.6430
Skewness	2.0554
Range	762952
Maximum	763289
Minimum	337
Sum	5043957
Count	37

B. Response variable

Figure 2 Plot of BNM personal loan applications

Figure 2 Plot of BNM personal loan approvals

Table 2 Summary of descriptive analysis of response variables

Table 3 Summary of descriptive analysis of response variable

BNM Personal Loan Approval data from January 2018 to June 2022	
Mean	1965.8020
Standard Error	51.2939
Median	1985.6375
Mode	-
Standard Deviation	376.9317
Sample Variance	142077.5060
Kurtosis	2.3005
Skewness	-1.1509
Range	1868.4230
Maximum	2528.0170
Minimum	659.5940
Sum	106153.3080
Count	54

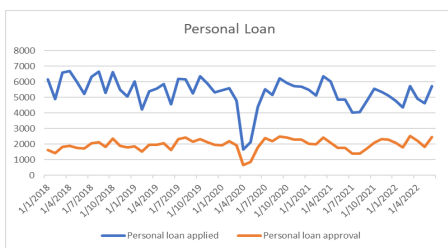| BNM Personal Loan Application data from January 2018 to June 2022	
Mean	5330.7671
Standard Error	131.2442
Median	5467.5455
Mode	-
Standard Deviation	964.4442
Sample Variance	930152.5655
Kurtosis	4.5269
Skewness	1.6369
Range	5044.6490
Maximum	6701.1560
Minimum	1656.5070
Sum	287861.4210
Count	54

Figure 3 Comparison of Personal Loan Approvals and Applications

The trend of personal loan approvals follows the trend of personal loan applications. Also, when the number of personal loan applications increases, the number of personal loan approvals increases.

C. Independent Variables

Table 4 Summary of Descriptive Analysis of Independent Variables

	Unemployment	Employment	Bank Interest	CPI
Mean	625.2859	15213.0309	6.1716	121.8463
Standard Error	15.3248	41.6598	0.0873	0.2728
Median	620.5685	15201.6000	6.2613	121.4000
Mode	516.4000	-	5.4896	121.1000
Standard Deviation	112.6140	306.1358	0.6416	2.0049
Sample Variance	12681.9186	93719.1276	0.4117	4.0195
Kurtosis	-1.7193	0.0752	-1.9334	0.7270
Skewness	0.2334	0.5558	0.0112	0.6825
Range	321.3000	1265.8000	1.4325	9.8000
Maximum	826.1000	14670.5000	6.9221	127.4000
Minimum	504.8000	15936.3000	5.4896	117.6000
Sum	33765.4380	821503.6680	333.2669	6579.7000
Count	54	54	54	54

D. Regression Analysis

Personal Loan Applications

In this result, R square is 0.3650, indicates that approximately 36.50% of the variance in the dependent variable is explained by the independent variables. The result of standard error is 791.2262. A higher standard error suggests that the predicted values of the dependent variable have a larger average deviation from the regression line.

Since than the significance F which is 4.18E-05 less than $\alpha = 0.05$, hence reject H_0 in this case. Rejection of H_0 implies that the regression coefficient differs from zero. That is at least one predictor variable is significant.

Based on the result Excel output in Table 7, the multiple linear regression model is

$$Y_1 = 23614.2012 - 1736.3529 \, Interest - 11.8736 \, Unemploy - 0.0017 \, Covid$$

Examining the coefficients and their corresponding standard errors, we find that bank interest, unemployment, and Covid exhibit p-values of 0.0007, 2.1E-05, and 0.0348, respectively. Since these p-values are all below 0.05, we can conclude that bank interest, unemployment, and Covid are statistically significant at the 5% significance level. This suggests that these variables have a true relationship with personal loan applications, and we reject the null hypothesis, H_0 for these variables.

Table 5 Regression Statistic of Personal Loan Applications

Regression Statistic	
Multiple R	0.6042
R Square	0.3650
Adjusted R Square	0.3270
Standard Error	791.2262
Observations	54

Table 6 ANOVA Table of Personal Loan Applications

ANOVA					
	Dof	**SS**	**MS**	**F**	**Significance F**
Regression	3	17996144.5745	5998714.8582	9.5820	4.18E-05
Residual	50	31301941.3984	626038.8280		
Total	53	49298085.9729			

Table 7 Summary Hypothesis Testing of Personal Loan Applications

	Coefficients	**Standard Error**	**t Stat**	**P-value**	**Lower 95%**	**Upper 95%**
Intercept	23614.2012	4489.8648	5.2594	3.02E-02	14596.0422	32632.3601
Interest	-1736.3529	481.8299	-3.6037	0.0007	-2704.1368	-768.5690
Unemploy	-11.3736	2.5278	-4.6973	2.1E-05	-16.9508	-6.7964
Covid	-0.0017	0.0008	-2.1702	0.0348	-0.0033	-0.0001

Personal Loan Approval

In this result, R square is 0.1420, which means that 14.20% of the variability in the dependent variable is explained by the independent variables. The result of standard error is 355.9264 representing the average deviation between the observed and predicted values.

Since the significance F which is 0.0201 less than $\alpha = 0.05$, hence reject H_0 in this case. Rejection of H_0 implies that the regression coefficient differs from zero. That is at least one predictor variable is significant.

Based on the result Excel output in Table 10, the multiple linear regression model is

$$Y_2 = -5672.19 + 17.9045\, CPI + 0.2632\, Employ$$

The p-values for the coefficients in the regression analysis are as follows: the intercept coefficient has a p-value of 0.0631, the CPI coefficient has a p-value of 0.7154, and the Employ coefficient has a p-value of 0.2674. These p-values indicate that only the intercept coefficient is marginally significant at the 5% significance level, while the CPI and Employ coefficients are not statistically significant.

Table 8 Regression Statistic of Personal Loan Approvals

Regression Statistic	
Multiple R	0.3768
R Square	0.1420
Adjusted R Square	0.1082
Standard Error	355.9264
Observations	54

Table 9 ANOVA Table of Personal Loan Approvals

ANOVA					
	Dof	SS	MS	F	Significance F
Regression	2	1069245.4762	534622.7381	4.2201	0.0201
Residual	51	6460862.3421	126683.5753		
Total	53	7530107.8183			

Table 10 Summary Hypothesis Testing of Personal Loan Approvals

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-5672.1900	2985.8241	-1.8997	0.0631	-11666.4819	322.1020
CPI	17.9045	48.8363	0.3666	0.7154	-80.1384	115.9475
Employed person	0.2632	0.3198	1.1214	0.2674	-0.2834	1.0007

E.   Correlation

Personal Loan Applications
Regarding personal loan applications, there is a weak positive correlation of 0.28 with bank interest and a very weak positive correlation with CPI. Unemployment shows a moderate negative correlation (-0.44), while COVID-19 status and employment show weak negative correlations (-0.23 and -0.11) with personal loan applications. These findings suggest that personal loan applications do not exhibit obvious correlations with the explanatory variables. Variables with neutral-colored squares can be excluded when forming a multiple linear regression model.
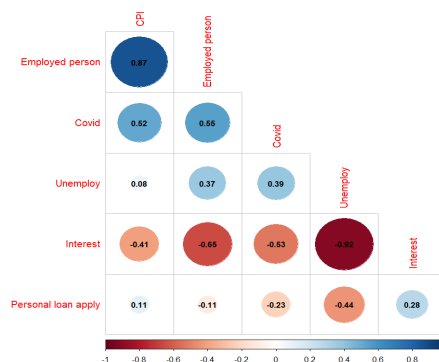

Figure 4 Correlogram of Personal Loan Applications

Figure 6 shows that bank interest has a strong positive relationship with personal loan application as it has the positive slope. Figure 7 shows that CPI has a weak positive relationship with personal loan application as it has the positive slope. Figure 8 shows that there exists weak negative relationship between employment and personal loan applications as there is a negative slope in the plot. Figure 9 shows that there exists moderate negative relationship between unemployment and personal loan applications as there is a negative slope in the plot. Figure 10 shows that there exists weak negative relationship between COVID-19 status and personal loan applications as there is a negative slope in the plot.
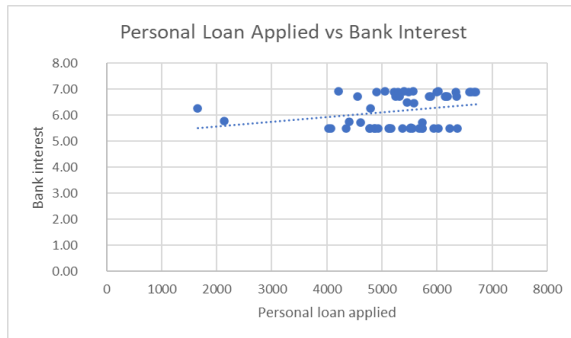
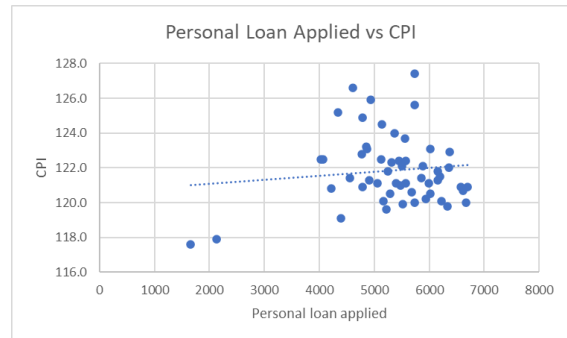**Figure 5** Scatterplot of Personal Loan Applied vs Bank Interest

Figure 6 Scatterplot of Personal Loan Applied vs CPI
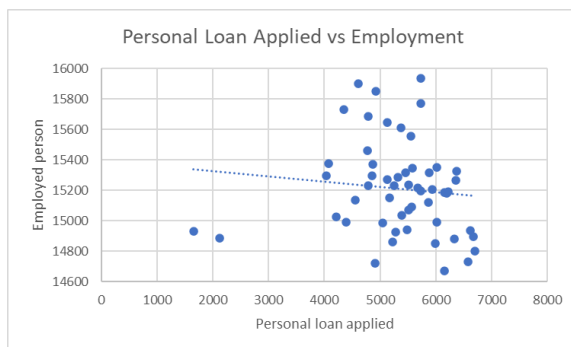

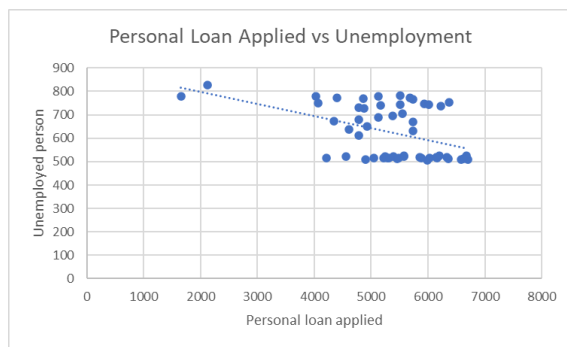**Figure 7** Scatterplot of Personal Loan Applied vs Employment

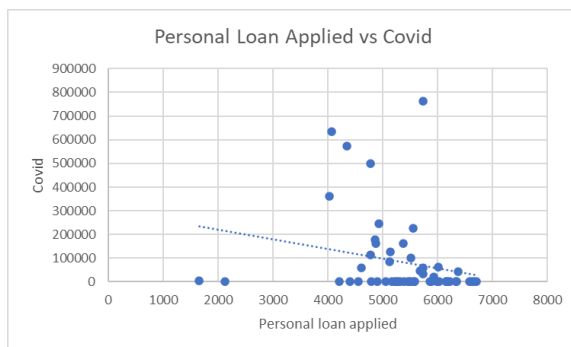**Figure 8** Scatterplot of Personal Loan Applied vs Unemployment

Figure 9 Scatterplot of Personal Loan Applied vs Covid

Personal Loan Approvals

Regarding personal loan approvals, there is a weak positive correlation of 0.37 with employment and 0.35 with CPI. Unemployment and COVID-19 status show very weak correlations of -0.07 and -0.04, respectively, with personal loan applications. This suggests that personal loan approvals do not exhibit strong correlations with the explanatory variables. Variables with neutral-colored squares may be excluded when constructing a multiple linear regression model.
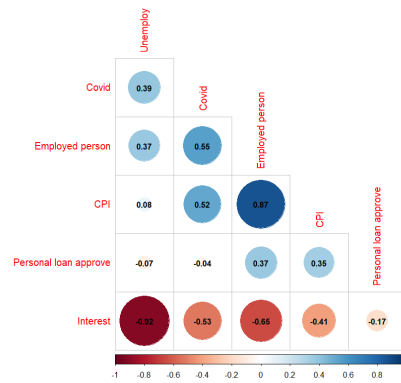
Figure 10 Correlogram of Personal Loan Approvals

Figure 12 shows that there exists strong weak negative relationship between bank interest and personal loan approvals as there is a negative slope in the plot. For the consumer price index in Figure 13, the scatterplot shows there is a moderate strong positive relationship with personal loan approvals. For the employed person in Malaysia (Figure 14), the scatterplot shows there is a weak positive relationship with personal loan approvals. Figure 15 shows that there exists fairly strong negative relationship between unemployed person in Malaysia and personal loan approvals as there is a negative slope in the plot. Figure 4.16 shows that there exists weak negative relationship between COVID-19 status and personal loan approvals as there is a negative slope in the plot.
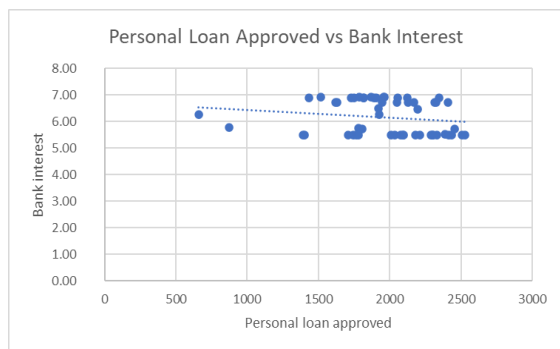

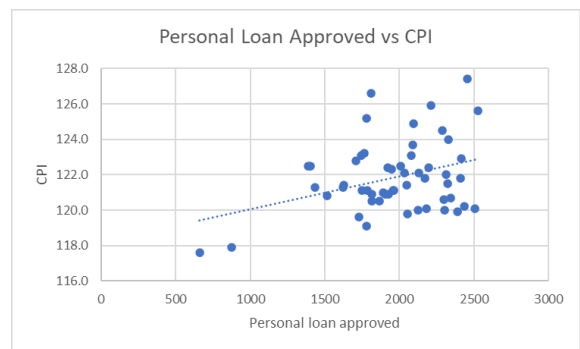**Figure 11** Scatterplot of Personal Loan Approved vs Bank Interest

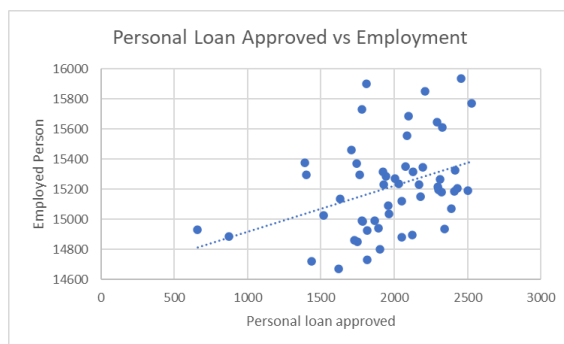**Figure 12** Scatterplot of Personal Loan Approved vs CPI

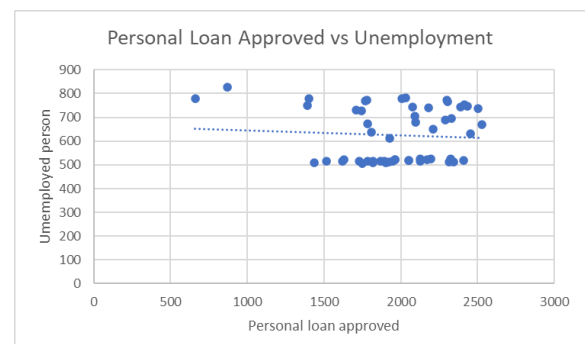**Figure 13** Scatterplot of Personal Loan Approved vs Employment

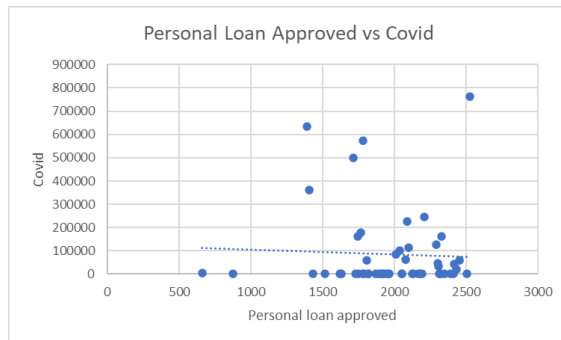**Figure 14** Scatterplot of Personal Loan Approved vs Unemployment

Figure 15 Scatterplot of Personal Loan Approved vs Covid

Conclusion

Based on the correlogram, the variables selected from the palettes with color are unemployment, COVID-19 status and bank interest, which have a moderate negative correlation, a weak negative correlation and a weak positive correlation with personal loan applications. While, the variables selected from the palettes with color are CPI and employment which have weak positive correlation with personal loan approvals. After the COVID-19 pandemic happened, there was more people apply personal loans to face with the unstable situation and slightly affected by the factors of unemployment and bank interest. The probability of getting approvals from BNM for a personal loan is higher during the COVID-19 pandemic and slightly affected by the factor of CPI. Future research will be focused on time series analysis in order to determine a better model for predicting personal loan growth, the implications of when banks approve too many loans and banks lend personal loans with lower interest and what effects this has on the economy of a country.

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