Community Purchase Decision Modeling in Bali with Non-Linier Methods

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ABSTRACT

The Covid-19 pandemic has resulted in all activities having to be carried out by implementing physical distancing or social distancing in accordance with health protocols for mutual safety. The government encourages people to do more activities at home, including shopping. Consumer perception of purchasing goods online is a process of evaluating various alternatives and choosing one alternative to purchase goods using internet media. The government appealed to the public to take advantage of online shopping to minimize the spread of Covid-19. This indicates that there are factors that influence consumer perceptions of purchasing goods online during the Covid-19 pandemic. The purpose of this study was to examine the effect of perceived convenience, perceived benefits, perceived trustworthiness, and product quality on people's purchasing decisions in Bali using the Structural Equation Modeling-Partial Least Square (SEM-PLS) approach, Support Vector Regression (SVR), and Feed Forward Neural Network (FFNN). Based on the results of the tests carried out, the SEM-PLS model is able to produce a model with an R2 value of 72.7% with a MAPE of 337.37, an SVR model of 65.88% with a MAPE of 219.56 and a FFNN model of 97.28% with a MAPE of 90.22. Based on the resulting R2 and MAPE values, the FFNN model gives the highest results compared to other models.

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1.   INTRODUCTION

Covid-19 in Indonesia was announced by the government for the first time in early March 2020 regarding the presence of Indonesian citizens who were positive for this virus. The existence of the Covid-19 pandemic has resulted in all activities having to be carried out by implementing physical distancing or social distancing in accordance with health protocols for mutual safety. Physical Distancing or Social Distancing is an effort to maintain social distance, so that with the condition of maintaining a distance we are encouraged to worship, work and study from home [1]. The government has implemented several strategies for the spread of the COVID-19 virus, including by gradually implementing Large-Scale Social Restrictions (PSBB) in areas where the COVID-19 virus is indicated. The PSBB continues, but the necessities of life during the PSBB period must always be met. Therefore, many people end up using e-commerce to shop for various consumer needs. For example, the habit of shopping at planning centers or stores is now starting to switch to using online media [2].

Online shopping is becoming a popular method among the public, this can be seen with the increasing number of online shopping transactions that have been carried out. According to Ernst and Young (1999) [3], convenience and greater savings are the two main reasons for the increasing interest in online shopping for consumers. Consumers can shop online anytime and anywhere. Consumers can save time and money when looking for information about an item/product and when shopping online. E-Commerce is a process of buying and selling products electronically by consumers and from company to company with computers as intermediaries for business transactions [2]. As an entrepreneur, learning to understand consumer behavior in making purchasing decisions is very useful. Intense competition and diverse consumer demands, understanding consumers is very important. Who is better able to understand consumer desires will win the competition. A consumer who has made a purchase decision will be satisfied if what he buys is in accordance with what is perceived. The buying decision made by the buyer is actually a collection of a number of decisions [3, 4]. In this case the perception of trust, comfort, perceived benefits, and product quality can have a direct effect on consumer satisfaction in online shopping and can have an indirect influence, namely through purchasing decisions.

Related to this, it is important for online business people to know in advance the factors and analyzes that influence online purchasing decisions during the COVID-19 pandemic, especially for people in Bali, so that online businesses must have and carry out the right strategy in order to make decisions. Internet users who have not made online purchases are interested in making online purchases and can retain existing customers. There are several methods that can be used for modeling online purchasing decisions in Bali, namely the Structural Equation Modeling (SEM) Method, Support Vector Regression (SVR), and Feed forward neural network (FFNN). Where from this research no one has ever conducted research related to modeling with the three existing methods using the same data, so they do not know for sure which method is more appropriate when using the same data.

Structural Equation Modeling (SEM) is a technique with a combination of path analysis and regression analysis that allows researchers to simultaneously test a series of interrelated relationships between the measured variables and latent constructs [2]. SEM analysis is a complex multivariate analysis, because it involves a number of independent variables and dependent variables that are interconnected to form a model. One of the variance or component-based SEM strategies is the Partial Least Square (PLS) method, where the data used to model structural equations does not have to be normally distributed and the sample size is relatively small. PLS is an analytical method used to confirm theory, and can also be used to explain whether or not there is a relationship between latent variables [2]. The results of research showing that the use of SEM can produce theoretical mechanisms of decision-making and provide empirical evidence [3, 4]. Other results suggest that using modeling of the least square partial structural equation (PLS-SEM) in investment decision making, has important implications for investors to understand themselves to anticipate bias in investment decision-making [5].

Support Vector Regression (SVR) is a model and development of SVM for regression and time series modeling. SVM is a learning system using a hypothetical space in the form of linear functions in a high-dimensional feature space. The SVM concept uses the -esensitive loss function concept which can be generalized to approach a function known as SVR [6]. The SVR concept is based on structural risk minimization, which is to estimate a function by minimizing the upper limit of the generalization error, so that SVR is able to overcome overfitting. The purpose of SVR is to obtain a function with the smallest error rate so as to produce a good prediction. In line with the results of research conducted by [7] which states that the support vector regression model has lower and stronger predictive errors. Other studies state that computational results show that hybrid SVR models are efficient tools, capable of performing more precise predictions of maximum pitting corrosion depth. In addition, the results revealed that the SVR-FFA model outperformed all other models considered in the study.

Feed forward neural network (FFNN) is one of the main types of neural networks, and the FFNN method is the most widely used method for making predictions [8]. The architecture of the FFNN model consists of one input layer, one or more hidden layers, and one output layer. In this model, the calculation of the response or output Y_k is done by processing input x flows from one layer forward to the next layer sequentially. Among various neural network models, FFNN is the model that is more often used because it is known to have good approximation capabilities and is universal. In addition, the FFNN method has been known for its advantages, namely it has a predictive value that is very close to the actual value so that it produces small errors and has the ability to detect or perform analysis for very complex problems. The FFNN method does not have certain conditions or assumptions [9].

References [10] researched on "Use of Structural Equation Modeling (SEM) to Analyze Factors Affecting Customer Loyalty (Case Study: PT Bank Negara Indonesia (BNI) KCU Ambon)". The results of the study indicate that the latent variable of bank image has an influence on customer loyalty while the latent variable of customer satisfaction has no effect on customer loyalty. References [11] researched the "Best Sem-Pls Model for Evaluation of Discrete Mathematics Learning With LMS". The results of the study indicate that the Main Model is better based on the value of Q2 compared to other models in this study. The results are different if the criteria used are AIC, AICu, AICc, BIC, HQ and HQc, where Models C2 and B2 are models based on these criteria. References [12] researched "The Application of Support Vector Regression (Svr) in Predicting the Number of Domestic Tourist Visits to Bali". The results of this study are based on forecasting using training data, the MAPE value obtained is 11, 34%, while using testing data, the MAPE value obtained is 7, 30%. Based on the resulting MAPE value, it can be categorized as good for predicting the number of tourism visitors.

References [13] researched "Comparison of the Seasonal Autoregressive Integrated Moving Average (SARIMA) with Support Vector Regression (SVR) in Predicting the Number of Foreign Tourist Visits to Bali". The results of data out sample forecasting using the SARIMA and SVR methods indicate that the SARIMA method has a smaller MAPE value than the SVR. The MAPE value of the SARIMA method is 5, 33% while the SVR method is 19, 74%. Likewise, the MSE and MAE values of the SARIMA method are smaller than the SVR method. From the research conducted, it can be concluded that the SARIMA model is a better method for predicting the number of foreign tourist visits to Bali. References [14] researched "Survival Modeling Using Support Vector Regression (SVR) on Bearing Vibration Data". The results of the study indicate that the SVR equation using the Kernel Gaussian RBF function obtained a value of 98.72% for data training and 97.96% for data testing. References [15] researched "ARIMAX, FFNN, and ARIMAX-FFNN modeling for rice production forecasting in Central Java Province". The results of the study show that the analysis of this study resulted in the best ARIMAX model being the ARIMAX model. While the best FFNN model is the FFNN model (1-27-1). The best Hybrid ARIMAX-FFNN model is model (2-19-1). The best model for forecasting rice production in the future period is using the ARIMAX model.

References [16] researched "Analysis of the Recognition of the Malay Clump State Flag Using the Feed Forward Neural Network (FFNN) Method". The results of the research are the results show that the use of 4 Hidden Layers, as well as the use of Learning Rate 0.5 provides the ability to recognize flag images correctly with an average percentage of accuracy reaching 74.15%. References [17] researched The Influence of Marketing Mix Variables on Purchasing Decisions and Its Impact on Post-Purchase Customer Satisfaction of Royal Garden Residence Bali Housing (Study at PT Properti Bali Benoa). The results of the study proves that there is an indirect influence of the marketing mix variable on consumer satisfaction after purchasing the Royal Garden Residence Bali housing through the purchase decision. References [18] researched Level 4 PPKM Implementation Effect Of Food And Beverage Purchase Decisions On Street Vendors In Jakarta Region.The results of this study obtained a regression coefficient of 0.255 with a significance value of 0.000 <0.05. It can be said that this research hypothesis is accepted because the PPKM Level 4 Application Variable (X) has a low positive effect on the Purchase Decision Variable (Y). References [19] researched The Influence Of Local Food Brand Image On Consumer Purchase Decision During Covid-19 Pandemic. The results showed that brand image and price had no significant effect on purchase intentions and food quality had no effect on purchase intentions. Meanwhile, the Purchase intention variable which is classified as moderate has a significant effect on the decision to purchase a local franchise during Covid-19.

The novelty of this study compared to previous research is that no previous research has examined the comparison of Structural Equation Modeling-Partial Least Square (SEM-PLS), Support Vector Regression (SVR), and Feed Forward Neural Network (FFNN) methods on decision data. online purchases for people in Bali during the covid-19 pandemic. In addition, the data were tested with a mediating effect. Taking this into account, the purpose of this study is to examine the effect of perceptions, perceived benefits, perceived trustworthiness, and product quality on people's purchasing decisions in Bali with the Structural Equation Modeling-Partial Least Square (SEM-PLS) approach, Support Vector Regression (SVR), and Feed Forward Neural Network (FFNN).

The next stage in this article is the research method, results and discussion, and conclusions. In part 2 the research method discusses the stages carried out in this research, including: research stages, identification of variables, how to test and obtain data. Section 3 is the results and discussion, in this section presents the results of the research. Section 4 contains the conclusions of the results of this study.

2. RESEARCH METHOD

The stages of research carried out in this study are identifying problems, analyzing problems, studying literature, collecting data, and then applying the SEM-PLS, SVR and FFNN methodologies. The stages of the research carried out can be described in Figure 1.
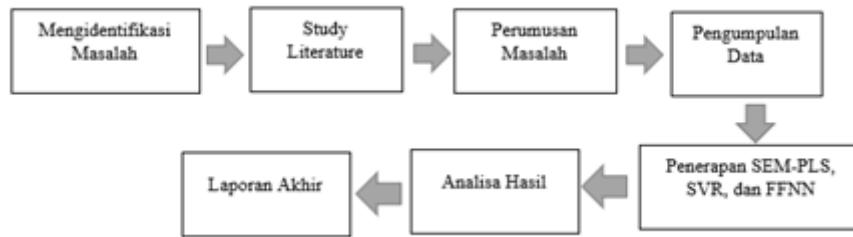
Figure 1. Research Stages

The variables used in this study include exogenous variables, moderator variables, and endogenous variables. The exogenous variables used in this study are perceived ease of use, perceived of Trust, and lifestyle and the moderator variable in this study is product quality and the endogenous variable is purchasing decisions (Table 1). The number of samples involved in this study were 97 people in Bali who made online purchases during the Covid-19 pandemic which were obtained through incidental sampling. Methods of data collection is done by using a questionnaire. The questionnaire was prepared using a grid that has been designed with a measurement scale using 4 response responses. The questionnaire that was made was then tested limited to 30 people to test the validity and reliability of the questionnaire. Questionnaires that have been valid and reliable are then used as research questionnaires. The data obtained from the research questionnaire was then analyzed using a predetermined method.

Table 1. Research Instruments

Variabel	Indicator
Buying decision Y	Needs Recognition/Problem Recognition
	Information search
	Alternative evaluation
	Buying decision
	Post-purchase behavior
Perception of Ease X1	clearand understandable
	does not require a lot of mental effort
	easy to use
	easy to get the system to do what he/she wants to do
Trust Perception X2	Ability
	Benevolence
	Integrity
Lifestyle X3	Activity
	Interest
	Opini
	Strength
Product quality X4	Dimension
	color scheme
	size
	shape

The data used in this study can be seen in the Table 2.

Table 2. Row Data

Case ID	Y	M1	M2	M3	X1	X2	X3	X4
1	-0.075	-0.064	-0.03	0.037	-0.729	-0.343	0.418	0.088
2	-0.481	-0.02	-0.013	0.027	1.327	0.835	-1.751	-0.015
3	1.045	0.002	0.008	-0.035	0.017	0.056	-0.251	0.139
4	-2.029	0.929	0.541	0.876	-1.147	-0.669	-1.083	-0.809
5	-0.481	-0.011	-0.03	-0.022	-0.129	-0.343	-0.251	0.088
6	0.832	0.158	0.811	0.542	0.316	1.627	1.087	0.499
7	0.566	0.908	1.336	0.286	1.327	1.953	0.418	0.684
8	-0.075	-0.064	-0.03	0.037	-0.729	-0.343	0.418	0.088
9	-0.481	-0.064	-0.03	0.037	-0.729	-0.343	0.418	0.088
10	-0.075	0.625	-0.352	0.428	0.61	-0.343	0.418	1.025
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
97	0.405	0.483	0.73	0.829	0.727	1.101	1.25	0.664

The research variables used in this study include:Y: purchasing decisions, X1 : perceived ease of use, X2 : perceived of Trust, X3 : lifestyle, X4 : product quality, M1 : interaction perceived ease of use with product quality, M2 : interaction perceived of Trust with product quality, M3 : interaction lifestyle with product quality. In this study, the analytical methods used are Structural Equation Modeling-Partial Least Square (SEM-PLS), Support Vector Regression, and Feed Forward Neural Network (FFNN). To calculate the goodness of the method used in this research, MAPE (Mean Absolute percentage error), MSE (Mean Square error) and R square are used. Each goodness of the model is shown in equations (1), (2), and (3).

$$MAPE = (\frac{1}{n}\Sigma_{i=1}^{n}|\frac{e_i}{Y_i}|) * 100\% \tag{1}$$

$$MSE = \frac{1}{n}\Sigma_{i=1}^{n}e_1^2 \tag{2}$$

$$R^2 = 1 - \frac{\Sigma_{i=1}^{2}(y_i - \hat{y_l})^2}{\Sigma_{i=1}^{2}(y_i - \bar{y})^2} \tag{3}$$

To achieve the research objectives, the following steps were used:

1. Perform analysis with Structural Equation Modeling-Partial Least Square (SEM-PLS)
   a. SEM Analysis of Moderating Effect
   b. Respondent descriptive test
   c. The formation of a moderating effect path structure where the exogenous variables used are perceived ease of use, perceived of Trust, and lifestyle. The endogenous variable is consumer purchasing decisions and the moderator variable is product quality.
   d. Evaluation of the outer model of the reflective indicator construct.
   e. Evaluation of formative indicator construct outer model.
   f. Evaluation of the structural model in this case the evaluation of the model with a moderating effect.
   g. Quality indexes.
   h. R square and MAPE based on the residual results obtained from the model
2. Perform analysis using Support Vector Regression. The data analysis is as follows:
   a. Divide the data into training data and testing data.
   b. Determine the type of kernel function and loss function used for forecasting.
   c. Specifies the value of C and the value of the kernel parameter.
   d. Look for beta and bias values.
   e. Forecasting the testing data.
   f. Calculates MAPE values.
   g. Determine the best kernel function, loss function and parameters, where the kernel function, loss function and the best parameters produce the smallest MAPE.
   h. Forecasting using the best kernel functions, loss functions and parameters.
   i. Calculate R square and MAPE based on the residual results obtained from the model.

The flowchart of each method used is shown in Figure 2 (SEM-PLS Method), Figure 3 (SVR Method), and Figure 4 (FFNN Method).
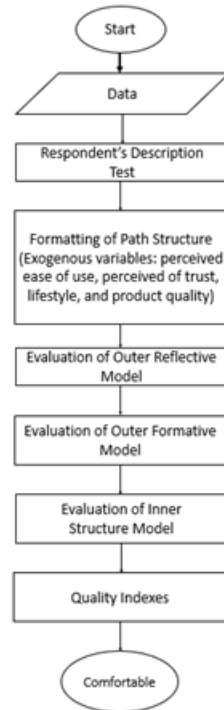

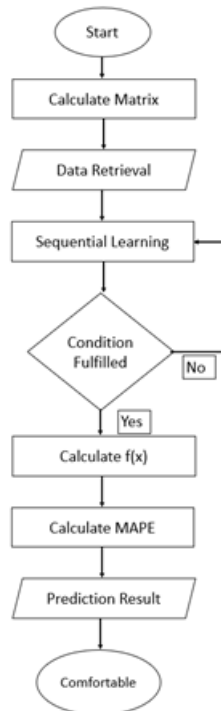Figure 2. Flowchart of SEM Analysis Moderation effect

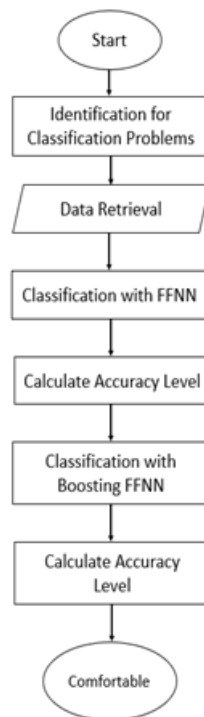Figure 3. Flowchart of the Support Vector Regression Method

Figure 4. Flowchart of Feed Forward Neural Network Method

3. Perform analysis with Feed Forward Neural Network (FFNN)
   a. Initialization. Assuming that no prior information is available and randomly select a very small value.
   b. Make training data as input. On the network, define the training cycle (epoch) of the training data.
   c. Forward computing. For example, the training data is denoted as ((n),(n)), with the input vector (n) in the input layer and the response vector (n) in the output layer. backward computing. Calculate the value of (local gradient).
   d. iteration. Iterate over the forward and backward computations in Steps 3 and 4 by assigning new epochs to the training data until the selected termination criteria are met.
   e. Calculate R square and MAPE based on the residual results obtained from the model

3. RESULT AND ANALYSIS

3.1. Instrument Validity and Reliability

Validity and reliability testing is carried out to ensure that the instruments compiled meet the valid and reliable criteria. Based on the results of the tests carried out, it was concluded that the instrument made had met the criteria of validity and reliability because the value of sig ¡0.05 and the CA value of more than 0.7.

3.2. Structure Equation Model Partial Least Square (SEM-PLS)

Figure 5 shows that the PLS model has a loading factor value of more than 0.6 so that the variables of perceived convenience, perceived risk, lifestyle, product quality and purchasing decisions meet convergent validity. Table 3 shows that the AVE root value of each variable is greater than the correlation value between variables. This indicates that the model meets discriminant validity. Table 4 shows the reliability value of Cronbach's Alpha, rho A, and composites from each variable more than 0.7 which indicates the model has met the reliability test.

Figure 5. Loading Factor Model PLS

Table 3. Discriminant Validity Evaluation Results

	Y	M1	M2	M3	X1	X2	X3	X4
Y	0.79							
M1	-0.32	1						
M2	-0.1	0.81	1					
M3	-0.15	0.8	0.75	1				
X1	0.71	-0.39	-0.21	-0.29	0.85			
X2	0.64	-0.16	0	-0.01	0.64	0.82		
X3	0.64	-0.2	-0.01	0	0.43	0.39	0.9	
X4	0.72	-0.24	-0.13	-0.11	0.59	0.65	0.52	0.79

Table 4. Reliability Test Results

Cronbach's Alpha & rho_A & Composite Reliability		
Y	0.8	0.8	0.87
M1	1	1	1
M2	1	1	1
M3	1	1	1
X1	0.92	0.93	0.94
X2	0.88	0.9	0.91
X3	0.78	0.78	0.9
X4	0.9	0.9	0.92

Table 5. Path Coefficient

	Original Sample (O)	P Values
M1 $\rightarrow$ Y	-0.091	0.302
M2 $\rightarrow$ Y	0.095	0.199
M3 $\rightarrow$ Y	0.007	0.92
X1 $\rightarrow$ Y	0.292	0.001
X2 $\rightarrow$ Y	0.124	0.258
X3 $\rightarrow$ Y	0.277	0
X4 $\rightarrow$ Y	0.301	0.001

The structural equation model formed from the results of the inner model coefficients in Table 5.

$$\eta_Y = 0,292\xi_1 + 0,124\xi_2 + 0,277\xi_3 + 0,301\xi_4 - 0,091\xi_{X_1*X_4} + 0,095\xi_{X_3*X_4} + \xi \tag{4}$$

Table 6. Coefficient of Determination and MAPE from SEM-PLS Model

R Square	R Square Adjusted	MAPE	MSE
0.727	0.705	337.37	0.27

Based on Table 6, the R2 value of the structural model obtained is 0.727 indicating that all variables of perceived ease of use, perceived of Trust, lifestyle, and product quality can have an influence on purchasing decisions during the pandemic period of 72.7% with MAPE value is 337.37.

3.3. Support Vector Regression (SVR)

The data used in the SVR method is the same data used in the SEM-PLS method. At this stage, several methods are used to obtain a model that produces the most optimal R2 value.

Before the data is analyzed, it is necessary to determine the kernel function and the lost function used. In this case, the kernel functions used are linear, polynomial, radial basis, and sigmoid. The kernel used in training and predicting. These four kernels were tested to get the best results. The lost functions used are Nu-regression and Eps-regression. These two functions are then combined with predefined kernel functions. After the kernel and the lost function are determined, the program is run to get the residual value, R2 and the MAPE value from each model. The test results are shown in Table 7.

Table 7. R^2 Value of SVR Model Based on Kernel and Type

Kernel	Type	R2	MAPE
Linear	**Nu-regression**	**0.714492**	**382.99**
Polynomial	Nu-regression	0.655186	259.37
Radial Basis	Nu-regression	0.542688	390.66
Sigmoid	Nu-regression	0.389659	800.05
Linear	Eps-regression	0.709589	294.12
Polynomial	**Eps-regression**	**0.658798**	**219.56**
Radial Basis	Eps-regression	0.564967	334.42
Sigmoid	Eps-regression	0.381637	689.58

Based on the results shown in Table 7, taking into account the model that has the lowest MAPE value, the model chosen is the model with the Polynomial kernel and the Eps-regression type, which is 219.56.

3.4. Feed Fordward Neural Network (FFNN)

Data modeling with FFNN is done by first determining or designing the activations in the program to be run. In this study, the training cycle (epoch) used was 1000 for all models to be tested. The input layer is 7 because the number of variables involved is 8, the hidden layer is 5 and the output is 1 layer. There are 3 activation functions used from the input layer to the hidden layer, namely Tansig, Logsig, and Pureline. Tansig is Hyperbolic tangent sigmoid transfer function. Logsig is Log-sigmoid transfer function. Pureline is Linear transfer function. Tansig, logsig, and pureline are transfer function. Transfer functions calculate a layers output from its net input. Each of these activation functions will be paired with an activation function from the hidden layer to the output layer using the pureline function.

There are 2 training functions used, namely Traingd and Transbfg. Traingd is gradient descent backpropagation. Traingd is a network training function that updates weight and bias values according to gradient descent.Trainbfg is BFGS quasi-Newton backpropagation. Trainbfg is a network training function that updates weight and bias values according to the BFGS quasi-Newton method. The estimation results of the model can be shown in Table 8.

Table 8. The R^2 value of the FFNN model is based on the activation value

Input layer activation function to hidden layer	Hidden layer activation function to output layer	training function	R^2	MAPE	MSE
Tansig	Purelin	Traingd	0.8739	359.03	0.336
logsig	Purelin	Traingd	0.85643	360.79	0.371
Purelin	Purelin	Traingd	0.85253	338.39	0.362
Tansig	Purelin	Trainbfg	0.9643	359.96	0.230
logsig	Purelin	Trainbfg	0.9728	90.22	0.159
Purelin	Purelin	Trainbfg	0.8525	338.38	0.362

Based on the results in Table 8, it is known that the model that gives the smallest MAPE value is the model with the activation function logsig and Purelin and the training function is Trainbfg. This model has a MAPE value of 90.22 with an R2 value of 0.9728. The plot results are shown in Figure 6-9.
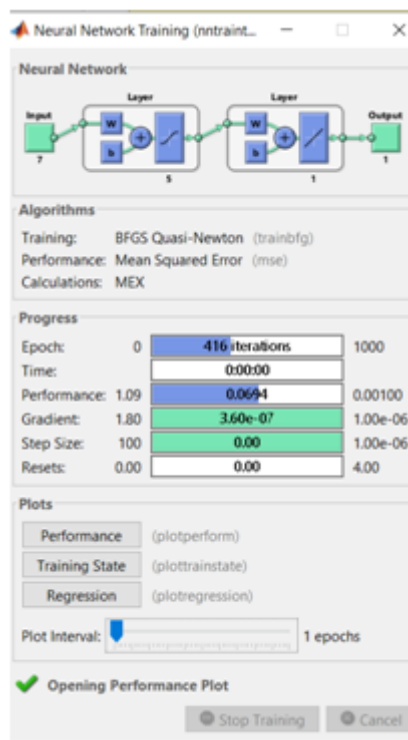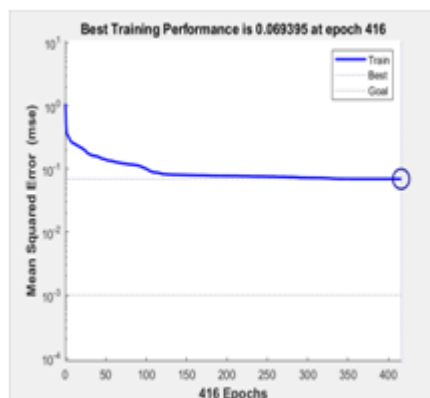

Figure 6. FFNN Process with Matlab
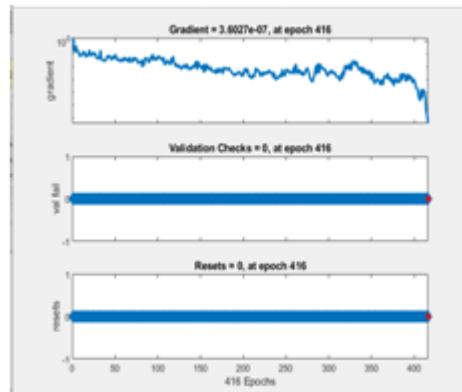

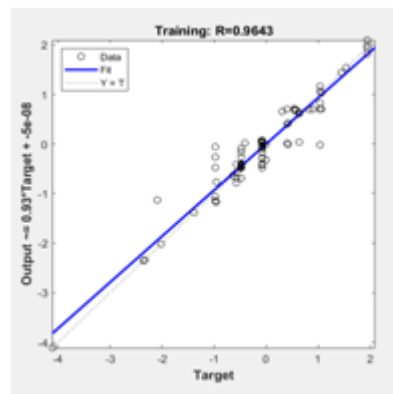Figure 7. Best Training Performance

Figure 8. Training Stage

Figure 9. Regression model

3.5. Comparison Model

Based on the results of the tests carried out, the SEM-PLS model is able to produce a model with an R2 value of 72.7% with a MAPE of 337.37, a SVR model of 65.88% with a MAPE of 219.56 and a FFNN model of 97.28% with a MAPE of 90.22. Based on the resulting R2 and MAPE values, the FFNN model gives the highest results compared to other models, but the resulting model is only a model consisting of outputs and targets where this target is built from the existing independent and moderator variables. In terms of model interpretation, the SEM-PLS model is more powerful because it is able to describe the relationship of each variable and is better than the SVR model when the model has a linear relationship. The results of this study are strengthened by research conducted by Ni Wayan Ayuni which states that the FFNN model is able to produce the best model when compared to the multiple linear regression model [20]. In addition, it is also supported by research by Ayu Mahdiah et al which states that the backpropagation model (FFNN) is a model that has the highest accuracy value compared to the SVR model.

4. CONCLUSION

Based on the results of the analysis, the conclusions that can be drawn from the research state that the SEM-PLS method is able to produce a model with an R2 value of 72.7%, the SVR method with a linear kernel and the Nu-regression type is able to produce a model with an R2 value of 71.44%, the FFNN method with with the activation function is Tansig with Purelin and the learning function is Trainbfg is able to produce a model with an R2 value of 96.43%. Of the three methods, the best model is the model formed from the FFNN method because it has the greatest value. In future research, the same test can be carried out but for moderating data in the case of non-linear data, or adding mediation effects in it. The novelty of this research is that by applying a different model approach, different results can be obtained. This provides an opportunity for analysis of purchasing decision data, which so far are still being analyzed using simple methods, which can be developed with better analysis in order to obtain more appropriate results.

ACKNOWLEDGEMENTS

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