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# Modeling the financial crisis in Indonesia

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ABSTRACT

*The purpose of this paper is to construct the model of the financial crisis in Indonesia through exchange market pressure index approach by using Multivariate Adaptive Regression Spline. This research used secondary data from the Central Bank of Indonesia from 2005 to 2014, consisting of 120 observations. The dependent variables are exchange market pressure index, and the independent variables consist of 11 macroeconomics variable. This research used the MARS 2.0 software, to build the model. The results shows 53.9% accuracy model of MARS and it obtains the smallest value of GCV that is 1.84, and the international interest rate of US Prime Rate is the most influential variable towards the exchange market pressure index. The results also provide additional knowledge regarding the indicators that can lead to the financial crisis based on the model established by the MARS approach. The implication is that the variable of international interest rate of US Prime Rate through the MARS approach can be an early warning system against the crisis that probably will happen, especially in Indonesia.*

ABSTRAK

*Penelitian ini bertujuan untuk membangun model krisis keuangan di Indonesia melalui pendekatan indeks tekanan pasar valuta dengan menggunakan Multivarian Adaptive Regression Spline. Penelitian ini menggunakan data sekunder dari Bank Sentral Indonesia dari tahun 2005 sampai dengan tahun 2014, terdiri dari 120 pengamatan. Variabel dependen dari penelitian ini adalah indeks tekanan pasar bursa, dan variabel independen terdiri dari 11 variabel makro ekonomi. Penelitian ini menggunakan software MARS 2.0, untuk membangun model. Hasil penelitian ini mendapatkan model akurasi 53.9% MARS dan memperoleh nilai terkecil GCV sebesar 1.84 adalah suku bunga internasional US Prime Rate sebagai variabel paling berpengaruh terhadap indeks tekanan pasar valuta. Hasilnya juga memberikan pengetahuan tambahan mengenai indikator yang dapat menyebabkan krisis keuangan berdasarkan model yang ditetapkan oleh pendekatan MARS. Implikasi dari penelitian ini, variabel suku bunga internasional US Prime Rate melalui pendekatan MARS dapat menjadi sistem peringatan dini terhadap krisis yang mungkin akan terjadi, terutama di Indonesia.*

## 1. INTRODUCTION

The financial crisis that hit Indonesia in mid-1997 brings a fairly fundamental change in the form of less favorable impact on some sectors, especially in the sectors of economy. The financial crisis originated from Thailand crisis, and then spread to other countries in Asia, such as Malaysia, Philippines, South Korea, and Indonesia. Actually, the financial crisis has repeatedly hit the Indonesian economy, for example, in 1978, 1983, and 1986. The financial crises were not as big as the financial crisis 1997. It was due to the crisis of 1997 that was followed by a social-political conditions deteriorate. The financial crisis that had affected Indonesia before 1997 belong to the crisis whose effects can still be managed like that in 2008. The recovery effort is also facing serious challenges, starting with the end of cooperation with the IMF (International Monetary Fund) up to the scandal in the Indonesian-banking world.

Research on the financial crisis was initiated by Krugman (1979) with the main indicators of observed changes in the real exchange rate, trade balance, real wages, and domestic interest rates. This model is known as the first generation model (First

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Generation Model), then this model was developed further by Flood and Garber (1984) by emphasizing that the crisis is a result of the budget deficit and is known as the second generation model (Second Generation Model). Then, it was also developed further by Obstfield and Rogoff (1996) and is known as the third generation model. In this model, the crisis occurred because of an attack of speculators who only speculate in economic transactions.

In the third generation, it used the approach as follows: First, non-parametric approach; including soft computing approach/neural network and its derivatives. Second, a parametric approach (logit/probit) using time series and cross section. Early detection of these studies is to plot between several macro-economic indicators as a predictor variable with the financial status as the response variable. The results of the plot does not show a clear pattern and there is a tendency to have a data plot regression curve changes in a given interval and not found any information on the theory or past experience regarding the shape of regression curve, so the method is less precise in modeling the crises.

Some research focuses on several variables that influence the financial crisis, such as Kaminsky et al. (1998). Such variables are the current account, short-term capital inflows, and foreign direct investment. Research by Cerra and Saxena (2000); uncertainty in politics and the effect of economic contagion caused the financial crisis, while in a study by Claporth (2004), it was found that the cause of the financial crisis is the GDP per capita, economic growth, net exports, inflation, foreign reserves, debt, and exchange rates.

The development in detection model of the financial crisis nowadays using a various approach that is very diverse. On international research examples there are research by Kaminsky et al. (1998), Berg and Pattilo, (1999), Cerra and Saxena (1999), Goldstein et al. (2000), Kim et al. (2003), Burkart and Coudert, (2002), Ahn et al. (2011) using Markov Switching Model, nonparametric approach (signal approach), a parametric approach (logit and probit), Linear Discriminant Analysis (LDA), Artificial Neural Network (ANN), and Support Vector Machine (SVM). Based on the model, research in the Indonesian financial crisis has less satisfactory results. This is because the model generally developed in the form of a generic model (global models) or a regional model (the collection of certain regions, such as emerging markets).

A nonparametric approach is used with MARS (Multivariate Adaptive Regression Spline). MARS method is used because it can cope with the weakness of Recursive Partitioning Regression (RPR) which resulted in a model that is continuous at knots. Additionally, MARS has been widely adopted by the computer science field as other competitor's methods such as artificial neural network (Artificial Neural Networks), Generalized Adaptive Models (Hastie and Tibshirani 1990) and, the classifications and Regression Tress (Breiman et al. 1993) which all aim to find the estimation models best approach to a real function. The research that uses MARS as a model to detect the financial crisis in Indonesia is expected could avoid the possibility of a financial crisis reoccur.

## 2. THEORETICAL FRAMEWORK AND HYPOTHESES

### Exchange Market Pressure Index

Generally, the financial crisis is defined as the decrease in the exchange rate of a country's currency against foreign currency (devaluation) caused by the pressure on the exchange rate market. Exchange market pressure index uses a formula developed by Heun and Schlink (2004) as follows:

$$EMPI = \left(\frac{1}{\sigma_p}\right)(\Delta_p) + \left(\frac{1}{\sigma_q}\right)(\Delta_q) - \left(\frac{1}{\sigma_r}\right)(\Delta_r). \quad (1)$$

EMPI : exchange market pressure index

$\sigma_p$ : Standard deviation of changes in the value of the rupiah against the US dollar

$\sigma_q$ : Standard deviation of changes in interest rates

$\sigma_r$ : Standard deviation of changes in foreign exchange reserves

$\Delta_p$ : Changes in the value of the rupiah against the US dollar

$\Delta_q$ : Changes in interest rates

$\Delta_r$ : Changes in foreign exchange reserves

What is the limit value of the index market pressures on the exchange rate that may indicate there has been a financial crisis in a country? That is the problem that needs to be answered. To get the answer of such problem, it is necessary to set a threshold on the index. Kaminsky defines a crisis if the index market pressures on the exchange rate exceeds the value - average index plus 3 times the standard deviation, while the World Bank defines 1.5 times the standard deviation (Kaminsky et al. 1996). In this study will be used as a reference is based on the version by the World Bank.

### Multivariate Adaptive Regression Spline (MARS)

Multivariate Adaptive Regression Spline (MARS) is one of the nonparametric regressions. This method can cope with the difficulties in the case of high-dimensional spline (curse of dimensionality).

MARS also determines the number and location of knots with a stepwise procedure of the data (Abraham and Steinberg 2001).

Friedman (1991) stated that MARS is a method with nonparametric regression approach that combines the spline with Recursive Partitioning Regression (RPR). This method has become popular because it does not assume a functional relationship fundamental and special (linear, logistic, etc.) between the predictor variables and the response variable (Otok, Subanar and Guritno 2006). In its development, MARS can be used to solve two major problems in statistics, a prediction at the time of continuous response variables and classification at the time of categorical response variables.

MARS model is useful for coping with the problem of high-dimensional data (Hastie, Tibshirani and Friedman 2008). In addition, MARS models also produce an accurate prediction of response variables, as well as produce a model that is continuous in knots by GCV smallest value (Friedman 1991). GCV (Generalized Cross Validation) is a method to obtain optimum knots. MARS was developed by Friedman (1991) for the nonparametric regression model approach between the response variable and several predictor variables on piecewise regression. Piecewise regression is a regression that has a segmented nature.

Nash and Bradford (2001) stated that two things need to be considered in the modeling of MARS is the knots and base functions. When a regression line cannot explain all the data then some regression line is used to describe all the existing data from the independent variables. Points change in the pattern or the regression line is what is called knots. Knot is the end of a regression line (region) and the beginning of a regression line to another. At each knot is expected continuity of basis functions between one regions to another region. While the base function is a function that is used to describe the relationship between the response variable and the predictor variable.

In the case above, Friedman (1991) suggested maximum number of basis functions (BF) two to four times the number of predictor variables. The maximum number of interactions (MI) is one, two, or three with consideration if more than three would produce models that are very complex. The minimum distance between the knots or minimum observation (MO) between the knots as zero, one, two, and three.

MARS is a development of Recursive Partitioning Regression (RPR) approach. RPR still has weaknesses because its does not produce continuous knots. Therefore, the MARS model is used to cope with the weaknesses of RPR which resulted in a model that is continuous on the knots. It can also identify the function of linear and additive. Improvements are being made to cope with the limitations of RPR, such as create basis functions becomes:

$$B_m(\mathbf{x}) = \prod_{k=1}^{K_m} \left[ s_{km} \cdot \left( x_{v(k,m)} - t_{km} \right) \right]_+ \quad (2)$$

Km is the number of interactions on the basis functions *m*, *tkm* is a knot of predictor variables, and has the value +1 if the knot located on the right or -1 if the knot located on the left sub region, *v* is the number of predictor variables, *m* is the number of basis functions and *k* is the number of interactions. Friedman modification, to cope with the weaknesses RPR, dan generate the MARS model as follows (Friedman 1991).

$$\hat{f}(\mathbf{x}) = a_0 + \sum_{m=1}^{M} a_m \prod_{k=1}^{K_m} \left[ s_{km} \cdot \left( x_{v(k,m)} - t_{km} \right) \right]_+ \quad (3)$$

With function,

$$\left( x_{v(k,m)} - t_{km} \right)_+ = \begin{cases} \left( x_{v(k,m)} - t_{km} \right), & x_{v(k,m)} - t_{km} > 0 \\ 0, & x_{v(k,m)} - t_{km} \le 0 \end{cases} \quad (4)$$

where $a_0$ is a constant coefficient of basis functions B0. Estimation for $\{\alpha_m\}_{m=0}^{M}$ determined using the least squares method (ordinary least square or OLS).

## 3. RESEARCH METHOD

### Operational Definition

The Index of market pressures, on the exchange rate (Exchange market pressure index) as a dependent variable, is a quantity that indicates a decrease in the value of a country's currency exchange rate against foreign currencies causes pressure on the exchange rate market. The definitions of the independent variables are as the following:

1. The growth of exports is the amount calculated on the value of transactions on goods and services sent abroad (x1).
2. The growth of import is the amount calculated on the value of transactions on goods and services imported from abroad (x2).
3. Foreign exchange reserves are reserves in units of foreign currency maintained by central banks to meets the financial obligations for their international transactions (reserve currency) (x3).
4. Inflation is one of the indicators to shows the

economic stability (rate of change in the price) of a region or area that shows the development of prices of goods and services in general are calculated from the consumer price index and the producer price index that follows changes in prices paid by consumers and producers (x4).
5. The value of the rupiah against the US dollar is the unit of Indonesia currency exchange rates against the currencies of United States of America (x5).
6. The money supply in a wider meanings is the monetary liabilities of a monetary system, which is consists of currency outside the monetary system, demand deposits and quasi-money (time deposits, savings in rupiah and foreign currency belonging to residents) (x6).
7. BI rate is the component which is used in determining the interest rates, both deposit and credit, as well as a reference for the lowest return on investment in Indonesia (x7).
8. Composite stock price index is a scale to see the development of stock prices in the stock market in Indonesia stock exchange (x8).
9. International interest rates LIBOR (London inter - bank offered rate) is the interest rate policy as a benchmark/standard to determine the level of interest rates in the interbank money markets abroad (London) (x9).
10. The international interest rate SIBOR (Singapore Inter-Bank Offered Rate) is the interest rate policy as Benchmark/Standard to determine the level of interest rates in the interbank money market, set by 8 (eight) leading bank in Singapore (x10).
11. International interest rates US prime rate is the interest rate policy as a benchmark/standard to determine the level of interest rates in the interbank money market, foreign (United States) (x11).

**Data and Data Collection Methods**

The data were the secondary data consisting of 120-monthly observations in 2005 until 2014. They were obtained from the Central Statistics Agency and Central Bank of Indonesia.

## 4. DATA ANALYSIS AND DISCUSSION

Data analysis used the stage steps to achieve the objectives described as follows:

1. Making a partial plot between the response variable (index of market pressures on the exchange rate) with a predictor variable to be used as early detection of the pattern of the relationship between the response variable and the predictor variable.
2. The descriptive analysis of each variable.
3. Established the MARS model.
   a. Defining the response variable and the predictor variables, where the predictor variables (The growth of exports and imports, foreign exchange reserves, inflation, the exchange rate, the money supply, BI rates, composite stock price index, LIBOR, SIBOR, international interest rates U.S. prime Rate) and the response variable (exchange market pressure index)
   b. Obtaining the best MARS model, it is done by trial and error by combining BF, MI and MO.
      1. Specifies the maximum basis function (max-BF), which is 2 s.d 4 times the number of predictors to be used.
      2. Specifies the maximum number of interactions (MI), which is 1 to 3, with the assumption that if MI> 3 will generate complex models.
      3. Specify a minimum number of observations of each knots (MO), ie 5, 10, and 20
      4. Determine the best model with the smallest value of GCV and the smallest MSE.

**Descriptive Analysis**

Descriptive analysis is an early stage exploration of the data to get a general overview of the data used in a study. Table 1 shows the description of the variables used in this study.

In the observation period 2005 through 2014, according to the World Bank, it requires a threshold value of the average index of the market pressure on the exchange rate plus 1.5 times of the standard deviation. The index gained an average of market pressure on the exchange rate (Y) of minus 0.13 with the lowest score of minus 5.23 (in December 2008) and the highest valued at 7.91 (in October 2008). In that condition, the standard deviation on all observations is 1.99. The next step analysis conducted in this research is to make the plot between the response variables with eleven predictor variables to determine whether there is a relationship between the response variable patterns and eleven of the predictor variables. A plot shows the relationship pattern of eleven predictor variables on the response variable is as in Figure 1.

From Matrix plot that has been obtained, it shows that each predictor variable has a different pattern and there is a tendency to have a data plot regression curve behavior changes in certain intervals and do not shows no a clear pattern. Moreover, with the limited information, the form function is based on theory or prior experience about the regression curve shape and the lack of relationship between the patterns of response variable with predictor variables into consideration to using a non-parametric approach, so the method selected to use is MARS method approach.

**The Establishment of MARS Model**

The phase to establish MARS model is by a combination of the maximum number of Basis Functions (BF), Maximum Interaction (MI) and the Minimum Observation (MO) between the knots until the optimal model is obtained with minimum GCV and the smallest MSE. The predictor variables were used in this study there were eleven variables, so that the number of basis functions (BF) used were as many as 22, 33, and 44 according to Friedman (1991), which advocated the selection of the maximum number of basis functions of two to four times that amount predictor variables.

Maximum interaction (MI) used in this study is 1, 2 and 3. Therefore, when more than 3 interaction, it will cause a very complex interpretation models. For minimum observation (MO) used, they are 5, 10, 20 so that, were at these points the minimum GCV values obtained (Sutikno 2008). Determine the best model of the combined value of BF, MI, and MO are possible with minimum GCV value criteria and the smallest MSE and perform parameter estimation. Criteria for selection of the best model are to compare the minimum GCV and the expected value of the MSE is also the smallest. The results from the combination of BF, MI and MO presented in the following tables:

The result of the combination of BF, MI and MO obtained value GCV smallest in combination BF = 33 predictor variables, MI = 3 and MO = 5 with a value of GCV = 1.840 with MSE = 1.015 and the value of the smallest MSE obtained in combination BF = 44 predictor variables, MI = 3 and MO = 5 with GCV value = 2.146 with MSE = 0.619. The best MARS model that obtained in each combination is as in Table 3.

Based on the analysis, it can be concluded as follows:

1. The best MARS models is obtained through a combination BF = 33, MI = 3, and MO = 5 that obtained smallest GCV and combinations BF = 44, MI = 3 and MO = 10 for PM
2. The advantage of the MARS method is that generated model can be from the interaction of multiple variables. In this case, the best MARS models accommodate the interaction between the three variables.
3. From the best MARS models with the smallest GCV, it gained 8 variables influencing the index market pressures on the exchange rate, which the international interest rate of US prime rate is the most influential variable with the degree of interest of 100%
4. From the best MARS models with the smallest MSE, it also obtained 9 variables influencing the index market pressures on the exchange rate, where the rupiah against the US dollar is the most influential variable with the degree of interest of 100%
5. The accuracy of the classification that obtained from the MARS models is 53.9% for the smallest GCV and 46.3% for the smallest MSE.

## 5. CONCLUSION, IMPLICATION, SUGGESTION, AND LIMITATIONS

In modeling the financial crisis of Indonesia with the MARS approach, the variables that obtained has contributed to the crisis which can be measured from the amount the index market pressures on the exchange rate (the exchange market pressure index) in the period 2005 to 2014 respectively. It is the international interest rates of the U.S. Prime Rate, the exchange rate, the money supply, composite stock price index, the international interest rate SIBOR, inflation, the growth of exports and, the international interest rates LIBOR. These results also provide additional knowledge regarding the indicators that can lead to financial crisis based on the model established by the MARS approach.

The implications of this research is that the variable international interest rate of US Prime Rate through the MARS approach can be an early warning system against crisis that probably will happen, especially in Indonesia. Although in this study only at the stage of modeling and have not reached the stage of prediction, the learning machine models with MARS approach is the appropriate model to be used as a tool to build an early warning system to the financial crisis, namely as a tool to find out as early as possible whether Indonesia has a crisis signal or not in the coming year.

This study has limitations on the data and variables. The data in the study only used the data from 2004 to 2014 and macroeconomic variables are used only 11 variables. Future studies are expected to increase the scope of data and variables of the research and also look for alternatives of other variables that may be the cause of the financial crisis.

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**Table 1**
**Description of Research Variables**

| Variable | Minimum | Maximum | Average | Standard Deviation |
|---|---|---|---|---|
| Y | -5.23 | 7.91 | -0.13 | 1.99 |
| X1 | -22.20 | 19.60 | 0.30 | 0.08 |
| X2 | -33.85 | 28.83 | 0.33 | 0.11 |
| X3 | 30.318.00 | 124,638.00 | 78,190.61 | 29,894.03 |
| X4 | -0.35 | 8.7 | 0.62 | 0.95 |
| X5 | 8,504.00 | 14,653.00 | 10,128.70 | 330.36 |
| X6 | 1,014,376.00 | 4,173,326.50 | 2,266,692.61 | 911,778.70 |
| X7 | 5.75 | 12.75 | 7.82 | 0.278 |
| X8 | 1,029.61 | 5,226.95 | 2,934.64 | 1,331.64 |
| X9 | 0.53 | 5.69 | 2.30 | 1.83 |
| X10 | 0.58 | 5.69 | 2.31 | 1.83 |
| X11 | 3.25 | 8.25 | 4.66 | 1.96 |

**Figure 1**
**Plot the Dependent Variables on the Independent Variables**

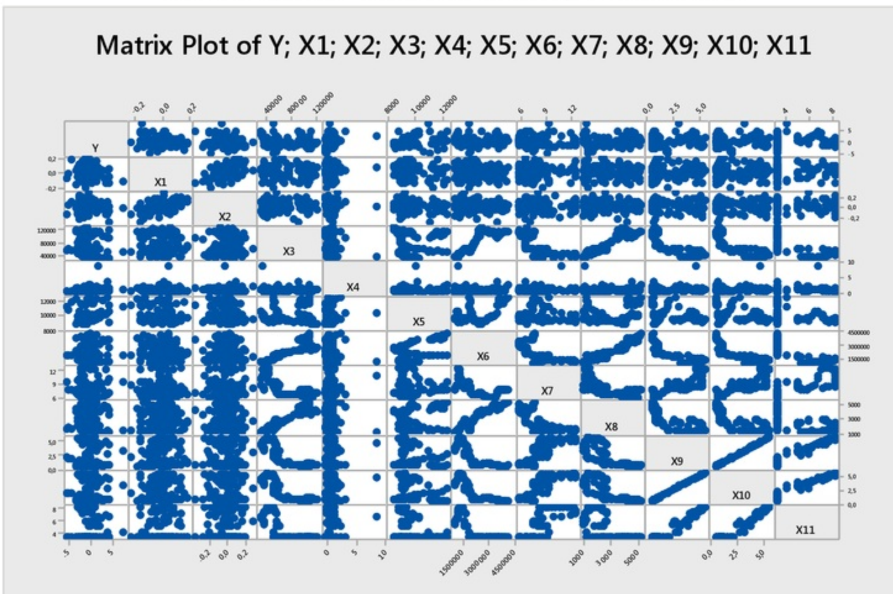

**Table 2**
**The Combination of BF, MI, and MO**

| Mi | Mo | BF = 22 | | BF=33 | | BF=44 | |
|---|---|---|---|---|---|---|---|
| | | GCV | MSE | GCV | MSE | GCV | MSE |
| 1 | 5 | 2.401 | 1.847 | 2.287 | 1.591 | 2.257 | 1.602 |
| | 10 | 2.374 | 1.763 | 2.588 | 1.93 | 2.443 | 1.956 |
| | 20 | 3.085 | 2.477 | 2.961 | 2.144 | 3.03 | 2.144 |
| 2 | 5 | 2.267 | 1.398 | 2.215 | 1.298 | 2.085 | 0.995 |
| | 10 | 2.546 | 1.586 | 2.108 | 1.081 | 2.232 | 1.197 |
| | 20 | 2.612 | 1.801 | 2.695 | 1.913 | 2.691 | 1.913 |
| 3 | 5 | 2.252 | 1.198 | 1.84 | 1.015 | 2.146 | 0.619 |
| | 10 | 2.55 | 1.696 | 2.466 | 1.787 | 2.757 | 1.778 |
| | 20 | 2.887 | 1.469 | 3.432 | 1.59 | 2.953 | 2.053 |

**Table 3**
**The Combination of BF, MI and MO that Has Best MARS Models**

| | Bf | Mi | Mo | GCV | MSE | R-square |
|---|---|---|---|---|---|---|
| Smallest GCV Model | 33 | 3 | 5 | 1.840 | 1.015 | 0.539 |
| Smallest MSE Model | 44 | 3 | 5 | 2.146 | 0.619 | 0.463 |

**Table 4**
**The Best MARS Models**

| MARS Models (Smallest GCV) | MARS Models (Smallest MSE) |
|---|---|
| BF5 = max(0, X11 - 5.000);<br>BF6 = max(0, 5.000 - X11 );<br>BF7 = max(0, X6 - 2217588.750);<br>BF10 = max(0, 10105.000 - X5 );<br>BF12 = max(0, 0.270 - X4 ) * BF6;<br>BF13 = max(0, X10 - 0.670) * BF7;<br>BF14 = max(0, 0.670 - X10 ) * BF7;<br>BF15 = max(0, X8 - 4418.760) * BF7;<br>BF16 = max(0, 4418.760 - X8 ) * BF7;<br>BF17 = max(0, X5 - 11360.000) * BF12;<br>BF19 = max(0, X10 - 1.070) * BF12;<br>BF21 = max(0, X9 - 1.020) * BF12;<br>BF25 = max(0, X8 - 4620.220) * BF6;<br>BF26 = max(0, 4620.220 - X8 ) * BF6;<br>BF28 = max(0, 1977532.375 - X6 ) * BF26;<br>BF30 = max(0, 11562.000 - X5 ) * BF6;<br>BF32 = max(0, 3790.850 - X8 ) * BF30;<br>BF33 = max(0, X1 + 0.222) * BF5;<br><br>Y = 2.822 - 0.002 * BF10 - 1.666 * BF12 - .109259E-04 * BF13<br>- .396209E-04 * BF14 + .981039E-08 * BF15 + .152699E-07 * BF16<br>+ 0.020 * BF17 - 102.632 * BF19 + 90.068 * BF21<br>- 0.010 * BF25 - 0.002 * BF26 + .175588E-07 * BF28<br>+ .118599E-05 * BF32 - 2.037 * BF33;<br><br>model Y = BF10 BF12 BF13 BF14 BF15 BF16 BF17 BF19 BF21 BF25 BF26 BF28 BF32 BF33; | BF1 = max(0, X8 - 1464.400);<br>BF2 = max(0, 1464.400 - X8 );<br>BF3 = max(0, X7 - 9.500) * BF2;<br>BF4 = max(0, 9.500 - X7 ) * BF2;<br>BF5 = max(0, X11 - 5.000);<br>BF6 = max(0, 5.000 - X11 );<br>BF7 = max(0, X6 - 2217588.750);<br>BF8 = max(0, 2217588.750 - X6 );<br>BF10 = max(0, 10105.000 - X5 );<br>BF11 = max(0, X4 - 0.270) * BF6;<br>BF12 = max(0, 0.270 - X4 ) * BF6;<br>BF14 = max(0, 0.670 - X10 ) * BF7;<br>BF15 = max(0, X8 - 4418.760) * BF7;<br>BF17 = max(0, X5 - 11360.000) * BF12;<br>BF19 = max(0, X10 - 1.070) * BF12;<br>BF21 = max(0, X9 - 1.020) * BF12;<br>BF22 = max(0, 1.020 - X9 ) * BF12;<br>BF23 = max(0, X3 - 50564.004);<br>BF25 = max(0, X8 - 4620.220) * BF6;<br>BF26 = max(0, 4620.220 - X8 ) * BF6;<br>BF27 = max(0, X6 - 1977532.375) * BF26;<br>BF30 = max(0, 11562.000 - X5 ) * BF6;<br>BF32 = max(0, 3790.850 - X8 ) * BF30;<br>BF33 = max(0, X3 - 71823.000) * BF30;<br>BF34 = max(0, 71823.000 - X3 ) * BF30;<br>BF35 = max(0, X9 - 5.240) * BF8;<br>BF36 = max(0, 5.240 - X9 ) * BF8;<br>BF37 = max(0, X6 - 1197771.875) * BF2;<br>BF39 = max(0, X4 - 0.450) * BF36;<br>BF43 = max(0, X7 - 5.750) * BF23;<br>BF44 = max(0, X5 - 8504.000) * BF36;<br><br>Y = 3.277 + 0.003 * BF1 - 0.003 * BF3 - 0.003 * BF4 - 2.696 * BF5<br>+ .114684E-04 * BF8 - 0.007 * BF10 - 0.571 * BF11<br>- .341002E-04 * BF14 + .119440E-07 * BF15 + 0.020 * BF17<br>- 118.724 * BF19 + 108.645 * BF21 - 9.387 * BF22<br>- .347541E-03 * BF23 - 0.011 * BF25 + .411701E-08 * BF27<br>+ .874481E-06 * BF32 + .672228E-07 * BF33 - .142554E-06 * BF34<br>+ .603227E-05 * BF35 + .590967E-07 * BF37 - .498572E-06 * BF39<br>+ .555320E-04 * BF43 - .387355E-08 * BF44;<br><br>model Y = BF1 BF3 BF4 BF5 BF8 BF10 BF11 BF14 BF15 BF17 BF19 BF21 BF22 BF23 |

**Table 5**
**The Effect of Each Independent Variable with the Smallest GCV and the Smallest MSE**

| Variable | Cost of Omission | Importance | Variables | Cost Of Omission | Importance |
|---|---|---|---|---|---|
| X11 | 3.096 | 100 | X5 | 4.802 | 100 |
| X5 | 3.849 | 98.615 | X11 | 4.743 | 98.890 |
| X6 | 3.740 | 95.889 | X6 | 4.334 | 90.77 |
| X8 | 3.446 | 88.172 | X3 | 4.120 | 86.203 |
| X10 | 3.003 | 75.009 | X90 | 3.747 | 77.641 |
| X4 | 2.720 | 65.263 | X8 | 3.509 | 71.630 |
| X1 | 2.118 | 36.648 | X7 | 3.351 | 67.353 |
| X9 | 1.904 | 17.576 | X4 | 2.804 | 49.788 |
| X2 | 1.840 | 0 | X10 | 2.480 | 35.3470 |
| X3 | 1.840 | 0 | X1 | 2.146 | 0.000 |
| X7 | 1.840 | 0 | X2 | 2.146 | 0.000 |

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10