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LEADING INDICATORS OF 2008 GLOBAL CRISIS: AN ANALYSIS WITH LOGIT AND MARS METHODS

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Abstract

This study aims to determine the leading indicators of the global mortgage crisis occurred in USA in 2008. Within this scope, we used 14 explanatory variables in order to understand the determinants of this crisis. Moreover, annual data for the periods between 1984 and 2014 was analyzed by using MARS and logit models so as to achieve this objective. As a result of the analysis, it was identified that non-performing loans and bank derivatives are the main indicators of this crisis according to MARS method. On the other hand, the amount of total assets and non-performing loans are significant reasons of the crisis with respect to the analysis of logit method. Another result of this study is that MARS method is more successful than logit method in order to predict the crisis.

Keywords: Banking Crisis, Early Warning Signal, MARS, Logit

Jel Codes: G01, G21, G33

2008 KÜRESEL KRİZİNİN ÖNCÜ GÖSTERGELERİ: LOGIT VE MARS YÖNTEMLERİ İLE BİR İNCELEME

Öz

Bu çalışmanın amacı Amerika Birleşik Devletleri'nde 2008 yılında başlayıp etkisini tüm dünyada gösteren küresel mortgage krizinin öncü göstergelerinin belirlenmesidir. Bu kapsamda, çalışmamızda krize etki ettiği düşünülen 14 adet bağımsız değişken kullanılmıştır. Ayrıca, 1984 ve 2014 dönem aralığındaki yıllık veriler MARS ve logit yöntemleri kullanılarak analiz edilmiştir. Elde edilen analiz sonuçlarına göre, MARS yöntemine göre takipteki krediler rakamı ve bankaların türev ürünlerinin mortgage krizinde etkili olduğu

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belirlenmiştir. Öte yandan, logit yöntemi ile yapılan analize göre ise takipteki krediler ve bankaların aktif büyüklüklerinin bahsi geçen krizin önemli nedenleri olduğu anlaşılmıştır. Çalışmamızda elde edilen diğer bir sonuç da MARS yönteminin logit yntemine kıyasla krizleri öngörebilmede daha başarılı olduğudur.

Anahtar Kelimeler: Bankacılık Krizleri, Uyarı Sinyaleri, MARS, Logit

Jel Kodları: G01, G21, G33

Introduction

Bank is a foundation that accepts money from depositors and gives this money to the investors (Freixas and Rochet, 2008, 15). Owing to the banks, depositors earn interest and investors can find sources for their investment much easily. Due to this situation, it can be said that banks play an essential role in an economy. Therefore, when there is a problem in banking sector, this situation will affect the whole economy negatively.

Additionally, the popularity of the banking sector increased very much especially with the effects of the globalization. Similar to this aspect, there is also increase in the risks which banks have to manage. However, it was seen that these risks could not be managed in some countries. As a result of this situation, many crises were occurred in last 30 years. Although most of these crises were started in developing countries, there were also some crises in developed countries.

The global financial crisis, started in USA in 2008, is an example of the crisis in developed economies. In a short time, negative effects of this crisis spread most of the world. A lot of banks went bankruptcy and many people lost their jobs because of this mortgage crisis. As a result of this crisis, the economy of the USA declined about 6.4% and total cost of this crisis was thought as 1.8 trillion USD (Ataman Erdönmez, 2009, 2).

Owing to these reasons, in this study, we tried to analyze the leading indicators of global mortgage crisis. Within this scope, we created models by using logit and MARS methods. As a result of this analysis, the reasons of this crisis can be identified. Thus, it will be possible to suggest policies in order for financial crisis not to occur again. In addition to this issue, it can also be determined which of these models are more successful so as to predict financial crisis. This is the first study which compared the results of logit and MARS methods in terms of predicting banking crisis.

The paper is organized as follows. After introduction part, we will give information about the similar studies in the literature. In the second part, we will explain the reasons and results of global mortgage crisis. Moreover, third part gives information about the details of the models used in the study. Furthermore, fourth part includes research and application to determine the leading indicators of this crisis. Finally, the results of the analysis were given at conclusion.

1. Literature Review

There are lots of studies in the literature about the early warning signals of the crisis. Some of them were detailed on the following table.

Table 1: Studies Related to Financial Crisis

Author	Scope	Method	Results
Frankel and Rose (1996)	105 different countries	Probit	They identified that devaluation is the main cause of the crises.
Demirgüç-Kunt and Detragiache (1997)	65 different countries	Logit	It was defined that lower growth rate and higher inflation cause the financial crisis.
Kaminsky, Lizondo and Reinhart (1998)	20 different countries	Signal Approach	They concluded that real exchange rate, export, M1 amount and growth rate are the reasons of the crisis.
Esquivel and Larrain (1998)	30 different countries	Probit	In conclusion, it was defined that current account deficit, volatility in exchange rate and lower growth rate are the main indicators of financial crisis.
Radelet and Sachs (1998)	22 different countries	Probit	They reached a conclusion that short term debt is the most important indicator of the crisis.
Berg and Pattillo (1999)	23 different countries	Signal Approach	It was identified that real exchange rate, domestic loans and interest rate cause the financial crisis.
Edison (2010)	20 different countries	Signal Approach	It was determined that real exchange rate, M2/reserves and stock prices lead to the crises.
Cartapanis, et. al. (2002)	6 Asian countries	Panel Data Analysis	They concluded that volatility in exchange rate is the main reason of the crisis.
Çeviş (2005)	22 developing countries	Panel Data Analysis	He defined that decrease in GDP growth and increase in current account deficit lead to financial crisis.
Kaya and Yılmaz (2007)	Turkey	Signal Approach	They reached a conclusion that public debt is the main cause of the crisis occurred in Turkey.
Altıntaş and Öz (2007)	Turkey	Signal Approach	They concluded that industry production index, capital outflow, lower GDP growth, interest rates and volatility in exchange rate cause financial crisis.
Çeşmeci and Önder (2008)	Turkey	Signal Approach	It was identified that real sector trust index is the most important early warning signal of the crisis.
Kahraman (2009)	15 developing countries	Panel Data Analysis	It was determined that current account deficit and high amount of domestic loans are the main indicators of the crisis.

Author	Scope	Method	Results
Çamoğlu, et. al. (2010)	5 developing countries	Cluster Analysis	They defined that low amount of GDP growth and high interest rate are the causes of the crisis.
Oktar and Dalyancı (2010)	Turkey	Probit	They reached a conclusion that lower reserves and current account deficit give the signal for the crisis.
Tunay (2010)	Turkey	MARS	It was identified that external factors, such as exchange rate open position, and terms of trade are the main indicator of banking crisis in Turkey.
Cebeci (2012)	Turkey	Probit	As a result of the analysis, it was defined that inflation, exchange rate, unemployment rate and lower GDP growth are the main indicators of the crisis.
Avcı and Altay (2013)	Turkey, Argentina, Thailand and England	Signal Approach	It was analyzed that interest rate, exchange rate and increase in domestic loans lead to financial crisis.
Yotzov (2014)	Bulgaria	Signal Approach	It was defined that low economic growth and interest rate are important indicator for Bulgaria during 2008 global crisis.
Karmakar and Vani (2014)	USA, India and Europe	Probit	They reached a conclusion that export rate and inflation are significant indicators of the crisis.
Soviani (2014)	Romania	Signal Approach	It was concluded that loan to deposit ratio, current account deficit and interest rate give signals for the economic crisis.
Sekmen and Kürkçü (2014)	Turkey	Artificial Neural Networks, Signal Approach	It was defined that artificial neural networks approach can predict the crisis better than signal approach.
Caggiano et. al. (2014)	35 African countries	Logit	They determined that low economic growth is the main reason of economic crisis in African countries.
Sevim et. al. (2014)	Turkey	Artificial Neural Networks, Logit	They concluded that artificial neural networks method is more successful than logit in order to predict the crisis.
Jdaitawi et. al. (2014)	Jordan	Signal Approach, Logit	They concluded that decline in reserves and increase in money supply (M2) raises the probability of currency crisis in Jordan.
Jo-Hui and Shih-Feng (2015)	China	Probit	It was identified that volatility in exchange rate are important signals for the crisis.

Author	Scope	Method	Results
Oktar and Yüksel (2015)	Turkey	MARS	It was concluded that derivatives with speculative purposes, inflation rates, net profit and short term foreign debt can be accepted as early warning signals of banking crisis in Turkey.
Megersa and Cassimon (2015)	Ethiopia	Signal Approach	It was determined that current account deficit is an indicator of financial crisis in Ethiopia.
Faranda, et. al. (2015)	USA	Auto Regressive Moving Average	They identified that volatility in stock market is an indicator of the financial crisis.
Sztojanov and Stamatescu (2015)	Hungary	Fuzzy Logic	It was determined that credit growth, housing prices and GDP gap are important determinant of the crisis.
Catullo, et. al. (2015)	Japan	Simulation	They analyzed that extraordinary increase in loans leads to financial crisis.
Kaur (2015)	USA	Probit	He concluded that short term debt is the most important indicator of global financial crisis.
Ionita and Stancu (2015)	Romania, Czech Republic and Hungary	Regression	It was concluded that the main important leading indicators are GDP growth rate, real effective exchange rate from trend and external debt.
Oktar and Yüksel (2015)	Russia	Probit	It was determined that the ratio of current account deficit to GDP and low profitability of the banks are important variables for Russian banking crisis.
Zhang, et. al. (2015)	16 historical bubbles	Quantile Regression	They defined that stock prices give important signals for the crisis.
Bucevska (2015)	Croatia, Macedonia and Turkey	Logit	It was concluded that short term external debt and high amount of public spending are leading indicators of the currency crisis for EU candidate countries.
Sztojanov et. al. (2016)	Romania	Fuzzy Logic	They identified that credit growth and real estate prices give significant information for potential crisis.
Christofides, et. al. (2016)	USA	Bayesian Model Averaging	They could not find an early warning signal for 2008 mortgage crisis.
Dawood (2016)	8 different countries	Logit	He created a new early warning signal model by using binominal logit method.
Hana and Al-Ghani (2016)	Jordan	Probit	They concluded that volatility in exchange rate, decrease in bank deposit and reserves are accepted as early warning signals for crisis in Jordan.

With respect to the studies related to financial crisis, it can be seen that some studies analyzed the many crisis in different countries together. Frankel and Rose (1996) analyzed financial crises in 105 different countries by using probit approach and concluded that devaluation is the main cause of the crises. Demirgüç-Kunt and Detragiache (1997), Kaminsky, Lizondo and Reinhart (1998), Berg and Pattillo (1999), Cartapanis and others (2002), Çeviş (2005), Edison (2010), Caggiano and others (2014), Zhang and others (2015) and Dawood (2016) also examined many crises and reached different results by using different methods.

In addition to them, in some studies, a crisis occurred in a country was analyzed. Soviani (2014) identified Romanian crisis by using signal approach. Megersa and Cassimon (2015) examined financial crisis in Ethiopia with the same technique. Moreover, Sztojanov and Stamatescu (2015) analyzed the financial crisis in Hungary and Sztojanov and others (2016) tried to identify the determinants of the economic crisis in Romania by using fuzzy logic method. Moreover, Christofides and others (2016), Jdaitawi (2014) and Hana and Al Ghani (2016) determined the early warning signals of the crisis occurred in Jordan.

There are also some studies in Turkey so as to determine the leading indicators of financial crisis. By using signal approach, Kaya and Yılmaz (2007) concluded that public debt causes economic crisis. Altıntaş and Öz (2007) and Çeşmeci and Önder (2008) reached different conclusion by using the same method. On the other hand, Oktar and Dalyancı (2010) and Cebeci (2012) analyzed financial crisis of Turkey while using probit approach whereas MARS method was used by Tunay (2010) and Oktar and Yüksel (2015).

Additionally, some researchers tried to compare the performance of two different methods with respect to the prediction of economic crisis. Sekmen and Kürkçü (2014) used artificial neural networks and signal approach in order to understand which methods are more successful to define the determinants of the crisis. Also, Sevim and others (2014) concluded that artificial neural networks method is more successful than logit in order to predict the crisis occurred in Turkey. Furthermore, Jdaitawi and others (2014) compared the performance of signal approach and logit in order to predict financial crisis.

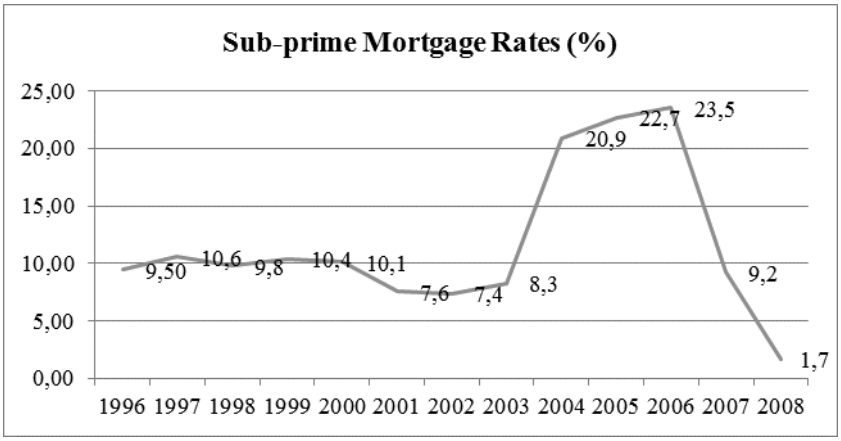
Moreover, there are also some studies in which early warning signals of global mortgage crisis was tried to determine. Faranda and others (2015) used auto regressive moving average and concluded that volatility in stock market is an indicator of the mortgage crisis. In addition to this study, Kaur (2015) identified that short term debt is the most important indicator of global financial crisis by using probit model. Furthermore, Christofides and others (2016) could not find an early warning signal for 2008 mortgage crisis by using Bayesian model.

2. 2008 Global Mortgage Crisis

In 2000, United States of America (USA) experienced an important financial crisis, which is called as "dot-com bubble". During this crisis, stock values of technology companies, such as NASDAQ declined dramatically. In order to minimize the negative effects of this crisis, FED

decreased interest rate very much so as to accelerate economic growth. As a result of lower interest rate, using loans became very attractive. In addition to this aspect, low level interest rate also pushed financial institutions and traders to create new investment instrument on derivate. This strategy is accepted as the main reason of the mortgage crisis started in 2008 (Kraay and Ventura, 2007, 460).

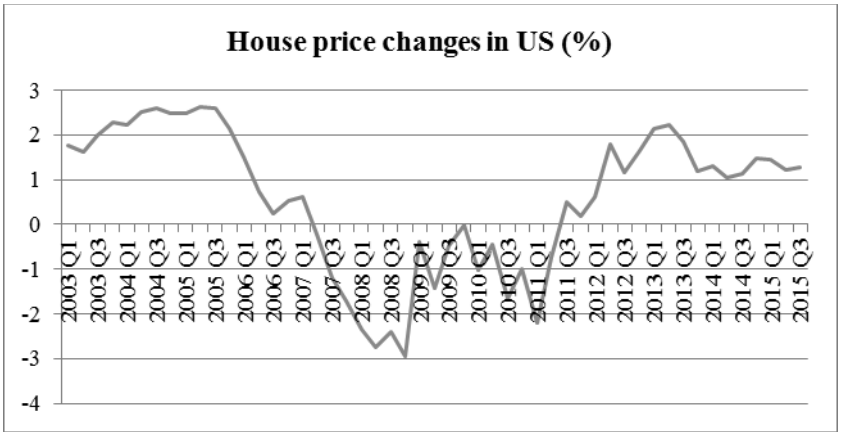
Moreover, rise in the amount of the loans also led to increase in consumption in the country. This situation also supported economic growth. This optimistic atmosphere pushed financial institutions and traders to create new investment instrument on derivate in order to increase the profit. Parallel to this issue, mortgage loans was restructured into the bonds and then these new instruments were sold to the investors (Stout, 2011, 27). Another import point during this period is the increase in real estate prices. This situation allowed the financial institutions to give mortgage loans to the people who have low level income. This type of mortgages was called as "subprime mortgages" (Azizov, 2009, 436). Following table shows the changes in the sub-prime mortgage rates over the years.



Graph 1: Sub-prime Mortgage Rates in USA (1996-2008)

Source: The Financial Crisis Commission, The Financial Crisis Inquiry Report, https://www.gpo.gov/fdsys/pkg/GPO-FCIC/pdf/GPO-FCIC.pdf

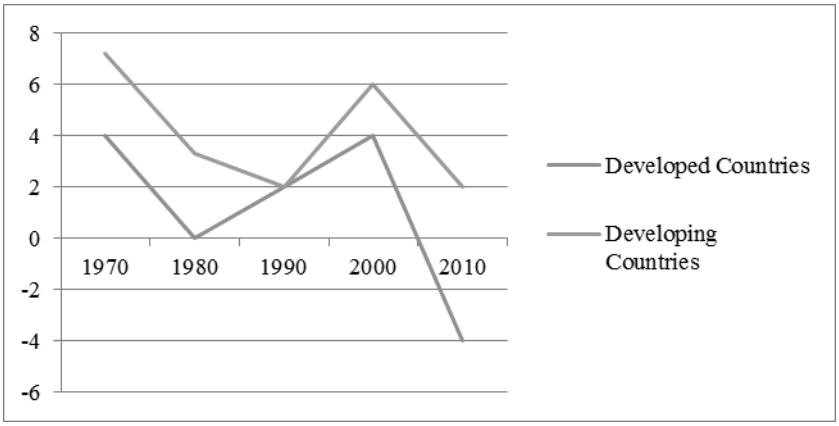
However, FED started to increase interest rates in order to prevent high inflation rates. As a result of this situation, the amount of loan installments began to go up. Consequently, customers, who have lower level income, could not pay their installments and non-performing loans ratio of the banks increased very much. Owing to these aspects, the prices of real estate started to decline in 2007 (Reinhart and Rogoff, 2008, 340). The details of prices changes are depicted on the following graph.



Graph 2: House Price Changes in the US (2003-2015)

Source: Global Property Guide, Real Estate House Prices, http://www.globalpropertyguide.com/real-estate-house-prices/U#united-states

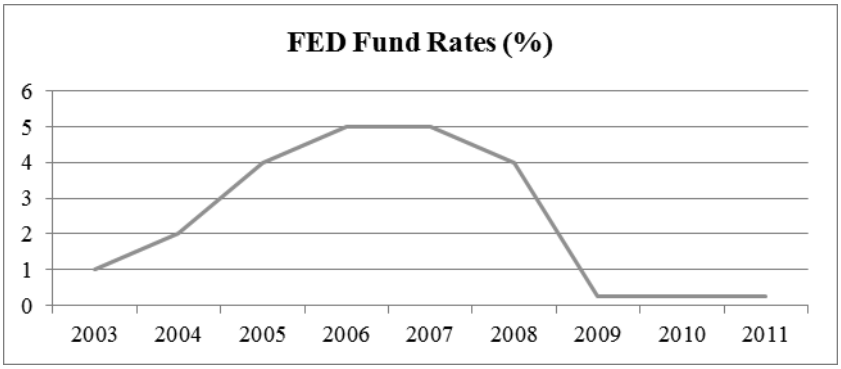
These negative events started to affect the economy of the country as well. In June 2007, one of the biggest investment banks in the US, Bear Stearns, announced large losses for its hedge funds. In addition to this situation, on September 15, 2008, Lehman Brothers, one of the biggest banks of world, went bankruptcy. This situation was accepted as the milestone of crises (Guillén, 2009, 7). This crisis also spread to Europe and developing countries. For example, in September 2007, the UK mortgage lender and bank Northern Rock was failed and was sold to UK government. The changes in the growth rates of developed and developing countries are given below.



Graph 3: Growth Rates of Developed and Developing Countries (1970-2010)

Source: IMF, World Economic Outlook, Crisis and Recovery, 2009, https://www.imf.org/external/pubs/ft/weo/2009/01/pdf/text.pdf

So as to prevent negative effects of the mortgage crisis, FED announced a recovery program that has the amount of 850 billion USD (Beck and Fidora, 2009, 359). Within this context, FED decreased to interest rates to 0.25% (Graph 4). In addition to this situation, US government took the control of Fannie Mae and Freddie Mac which had high amount of loss. Furthermore, AIG, which is the biggest insurance company, was rescued by the government with the help of 85 billion USD.



Graph 4: FED Fund Rates (2003-2011)

Source: FED, The Aftermath of the Crisis, https://www.federalreserve.gov/newsevents/files/bernanke-lecture-four-20120329.pdf

3. The Methods Used in the Study

3.1. Logit

Logit is a regression model in which dependent variable is categorical, such as "yes-no". The main difference of logit model from other methods is that logistic distribution function is used in this model. The details of this function are emphasized below.

$$F(Y_i) = 1 / (1 + e^{-Yi}) = 1 / (1 + e^{-(B0 + BiXi + \varepsilon i)}) \quad (1)$$

In this equation, "Y" represents dependent variable while "X" shows independent variable. Additionally, "B" demonstrates coefficient of explanatory variables and "ε" explains error term. On the other hand, "e" equalls to 2.72. Because this number is more than "0", this equation will always be positive. Also, since the denominator is greater than the nominator, this equation is less than "1".

Owing to this situation, logit model can be used in order to analyze early warning signals of the crisis (Demirgüç-Kunt and Detragiache, 1997, 81), (Gerni et. al., 2005, 1). In these type of studies, dependent variable takes the value of "1" during the crisis period whereas it is "0" in other years.

3.2. MARS Method

Multivariate Adaptive Regressin Splines (MARS) method, which was developed by Jerome Friedman in 1991, is used in order to define the effects of independent variables on dependent variable (Friedman, 1991, 1). In the process of creating model in MARS method, first of all, basis functions are created by using the different combinations of independent variables. This process continues until the maximum number of basis functions is reached. After this process, some of the basis functions, which decrease the level of significance of the model, are eliminated. As a result, we can obtain the most ideal model that has lowest error of estimation (GCV) and highest R^2 values.

MARS model is explained on the following equation.

$$Y = B_0 + \sum_{n=1}^{K} a_n B_n(X_t) + \varepsilon \quad (2)$$

On the equation above, "Y" represents dependent variable whereas "X" explains the independent variable. Also, "B_0" shows constant term and "a_n" demonstrates the coefficient of nth basis function. In addition to them, "K" refers to the number of basis functions and "ε" shows the error term.

MARS has many advantages in comparison with other methods. First of all, in MARS method, there is no multicollinearity problem that shows high correlation between explanatory variables in a regression (Friedman, 1991, 60). Additionally, MARS method uses (smoothing splines instead of straight line in order to define the relationship between dependent and independent variables (Friedman, 1991, s.7). Moreover, explanatory variables can take more than one coefficient in MARS model. Because of this issue, more accurate results can be achieved.

In addition to them, some information should be embedded into the system while creating a model by using MARS method. Firstly, velocity factor, which takes the values between 1 and 5, should be completed. Lower value of velocity factor increases the accuracy level of the model (Tunay, 2011, s.85). Also, in "maximum interaction among variables" space, researchers should enter some values in order to define how many variables can be interacted each other at the same time (Friedman, 1991, s.60).

Because MARS is a very new model, there are a few studies in which this model was used. Additionally, less of these studies are related to economy and finance. Moreover, similar to the logit model, MARS method was also used so as to analyze financial crisis and recession (Sephton, 2001, s.39), (Tunay, 2010, s.36), (Tunay, 2010, s.17), (Oktar and Yüksel, 2015, s.37).

4. Econometric Analysis

4.1. Data and Methodology

In this study, annual data for the period between 1984 and 2014 was used. This data was provided through the web sites of World Bank and Central Bank of America. In addition to this situation, SPSS 22 program was used in logit analysis and MARS 2.0 program of Salford Company was used in MARS method.

4.2. Variables Used in the Study

The economic crisis occurred in USA in 2008 was used as dependent variable in our study. In order to define the crisis period between 1984 and 2014, we analyzed industry production index and growth rate of USA. The values of these variables during crisis period were given on the following table.

Table 2: Industry Production Index and Growth Rate of USA (2005-2011)

Year	Industry Production Index	Growth Rate
2005	98.63	3.08
2006	100.82	2.66
2007	89.56	1.91
2008	87.04	-0.36
2009	92.72	-3.53
2010	95.52	3.02
2011	99.47	1.70

Source: World Bank

As it can be seen from the table above, the effect of the crisis started in 2007. In this year, there was a decrease in both industry production index and growth rate. In addition to them, it was identified that both of these variables were on the rise in 2010. Owing to these results, we gave the value of "1" to our dependent variable in 2007, 2008 and 2009 whereas it was "0" in other years. Moreover, we also used 14 different independent variables so as to define leading indicators of the mortgage crisis. The details of these variables were given below.

Table 3: Independent Variables Used in the Model

The Type of the Variables	The Name of the Variables	Reference
Macroeconomic Variables	Current Account Deficit	Oktar and Yüksel (2015), Berg et. al. (1999), Berg and Pattilo (1999), Bussiere and Fratzscher (2006), Davis and Karim (2008), Cashin and Duttagupta (2008), Edison (2000), Hardy and Pazarbaşoğlu (1998), Kaminsky et. al. (1998), Vlaar (2000), Gerni et. al. (2005), Erkekoğlu and Bilgili (2005), Altıntaş and Öz (2007)
	Real Interest Rate	Oktar and Yüksel (2015), Demirgüç-Kunt and Detragiache (1997), Barrell et. al. (2010), Berg et. al. (1999), Berg and Pattilo (1999), Davis and Karim (2008), Ergüngör and Thompson (2005), Caprio and Klingebiel (2002), Cashin and Duttagupta (2008), Edison (2000), Erdoğan (2008), Frankle and Rose (1996), Trigo and Costanzo (2007), Vlaar (2000), Gerni et. al. (2005), Erkekoğlu and Bilgili (2005), Altıntaş and Öz (2007)
	Public Debt	Oktar and Yüksel (2015), Edison (2000), Frankle and Rose (1996), Ovideo (2003), Erkekoğlu and Bilgili (2005), Kaya and Yılmaz (2007), Altıntaş and Öz (2007)
	Household Consumption	Oktar and Yüksel (2015), Frankle and Rose (1996), Ovideo (2003)
	Inflation	Oktar and Yüksel (2015), Demirgüç-Kunt and Detragiache (1997), Barrell et. al. (2010), Davis and Karim (2008), Cashin and Duttagupta (2008), Vlaar (2000), Gerni et. al. (2005), Erkekoğlu and Bilgili (2005), Kaya and Yılmaz (2007)
	Growth Rate	Oktar and Yüksel (2015), Demirgüç-Kunt and Detragiache (1997), Barrell et. al. (2010), Bussiere and Fratzscher (2006), Davis and Karim (2008), Caprio and Klingebiel (2002), Cashin and Duttagupta (2008), Frankle and Rose (1996), Hardy and Pazarbaşoğlu (1998), Erkekoğlu and Bilgili (2005), Kaya and Yılmaz (2007)
	Public Saving	Oktar and Yüksel (2015), Frankle and Rose (1996), Ovideo (2003)
	Unemployment Rate	Oktar and Yüksel (2015), Caprio and Klingebiel (2002), Erkekoğlu and Bilgili (2005)

The Type of the Variables	The Name of the Variables	Reference
Internal Variables	Non-performing Loans	Oktar and Yüksel (2015), Bussiere and Fratzscher (2006), Davis and Karim (2008), Herring and Wachter (1998), Borio et. al. (2001), Davis and Zhu (2004), Caprio and Klingebiel (2002), Cashin and Duttagupta (2008), Frankle and Rose (1996), Kolari et. al. (2002)
	Bank Derivatives	Oktar and Yüksel (2015), Ghysels and Seon (2005),
	Net Interest Margin	Oktar and Yüksel (2015), Erdoğan (2008), Kolari et. al. (2002), Caprio et. al. (2010), Caprio et. al. (2014)
	Return on Asset	Oktar and Yüksel (2015), Erdoğan (2008), Kolari et. al. (2002)
	Total Assets	Oktar and Yüksel (2015), Demirgüç-Kunt and Detragiache (1997), Barrell et. al. (2010), Berg et. al. (1999), Berg and Pattilo (1999), Davis and Karim (2008), Ergüngör and Thompson (2005), Caprio and Klingebiel (2002), Cashin and Duttagupta (2008), Sastrosuwito and Suzuki (2011)
	Total Loans	Oktar and Yüksel (2015), Demirgüç-Kunt and Detragiache (1997), Barrell et. al. (2010), Berg et. al. (1999), Berg and Pattilo (1999), Davis and Karim (2008), Ergüngör and Thompson (2005), Caprio and Klingebiel (2002), Cashin and Duttagupta (2008), Edison (2000), Erdoğan (2008), Frankle and Rose (1996), Hardy and Pazarbaşoğlu (1998), Kaminsky et. al. (1998), Ovideo (2003), Altıntaş and Öz (2007)

We used 14 explanatory variables in order to predict the determinants of global mortgage crisis. 8 of them are macroeconomic variables whereas there are also 6 variables which are related to banking sector. Current account deficit is the first macroeconomic variable. Because it increases the fragility in the economy, we expect that there is a positive relationship between this variable and the crisis (Yüksel, 2016, 103). Additionally, increase in real interest rate, public debt, inflation and unemployment rate also raises the probability of financial crisis due to the same reason. On the other hand, decrease in household consumption and lower economic growth can be the reasons of economic crisis.

In addition to the macroeconomic variables, there are also 6 explanatory variables related to the banking sector. Because the ratio of non-performing loans to total loans decreases the profit of the banks, we expect positive relationship between this ratio and crisis. Moreover, if the ratio of bank derivatives to total loans increases, this means that these derivatives are used with speculative purposes rather than hedging purposes (Oktar and Yüksel, 2015, 50). The main reason behind this situation is that if the derivatives are used with hedging purposes, the rise of them should be similar to the increase in loans. Therefore, there should be positive relationship between this ratio and economic crisis. Furthermore, decrease in net interest margin and return on assets is expected to increase the risk of the crisis. In addition to them, we used the log values of

total assets and total loans. Nevertheless, the relationship between these variables and economic crisis depends on the quality of these variables.

4.3. Analysis Results and Findings

First of all, we analyzed whether explanatory variables are stationary or not. Within this context, 14 independent variables were tested by using Augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root tests. EViews 8.0 program was used in this process and the details of this analysis were emphasized on the table below.

Table 4: ADF and PP Unit Root Test Results

Variable	Augmented Dickey Fuller (ADF) Test		Phillps Perron Test	
	Level Value (Probability)	First Difference Value (Probability)	Level Value (Probability)	First Difference Value (Probability)
Current Account Deficit	0.9064	0.0079	0.7951	0.0079
Real Interest Rate	0.0747	0.0069	0.3531	0.0061
Public Debt	0.9573	0.0068	0.9348	0.0089
Household Consumption	0.4862	0.0043	0.0882	0.0000
Inflation	0.0511	0.0005	0.2046	0.0000
Growth Rate	0.0793	0.0000	0.0593	0.0000
Public Saving	0.3711	0.0001	0.5331	0.0001
Unemployment Rate	0.2622	0.0024	0.6322	0.0054
Non-performing Loans	0.3188	0.0002	0.3433	0.0480
Bank Derivatives	0.4760	0.0161	0.9998	0.0383
Net Interest Margin	0.3356	0.0034	0.5561	0.0069
Return on Asset	0.3673	0.0145	0.4237	0.0002
Total Assets	0.5579	0.0423	0.7497	0.0466
Total Loans	0.9203	0.0209	0.6674	0.0268

As it can be seen from the table above, because probability values are higher than "0.05", all 14 explanatory variables are not stationary on their level values. Therefore, the first difference of these variables was used in our study. We made two different analyses by using logit and MARS models. The details of this analysis were stated in the following subtitles.

4.3.1. The Results of Logit Method

Firstly, we intended to make a model by using 14 different explanatory variables. However, due to the multicollinearity problem, we had to eliminate some variables from the model. As a

result, it was determined that 2 independent variables can explain the dependent variable. The details of the analysis were given below.

Table 5: The Results of Logit Analysis

Independent Variable	Coefficient	Significance
Non-performing Loans	6.839	0.024
Total Assets	-96.638	0.004
Dependent Variable: Financial Crisis		

As it can be seen from the table, the probability values of 2 independent variables are less than "0.05". This situation shows that they are statistically significant in order to explain financial crisis. Non-performing loans ratio is the first variable that causes financial crisis. Because its coefficient is positive (6.839), it can be said that there is a direct relationship between non-performing loans and financial crisis. In other words, higher non-performing loans can be accepted as a leading indicator of the mortgage crisis. The main reason behind this issue is that non-performing loans decreases the profit of the banks and this causes crisis in banking sector. Also, it can be said that higher amount of non-performing loans shows that people in the country are in a bad economic situation.

Furthermore, it was seen that total assets of the banks also give the signal for mortgage crisis. Since the coefficient is negative (-96.638), it can be said that there is an inverse relationship between total assets of the banks and mortgage crisis. If total assets of the banks go down, this means that banking sector is declining and banks will give less loans to the companies. This situation slows the economic activities in the country. Owing to this aspect, a recession period will be occurred.

Table 6: R-Square Results of Logit Analysis

Type of R-Square	Values
Cox and Snell	0.606
Nagelkerke	0.808
McFadden	0.672

The table above shows R-square results of the logit analysis. As it can be seen from this table, Negelkerke has the highest R-square value (0.808). According to this analysis, independent variables can explain 80.8% of the dependent variable. In addition to this aspect, we also made multicollinearity analysis of significant variables. With respect to the collinearity statistics, VIF value of all variables are less than "10" (App 1a). In addition to this situation, it was also identified that

the ratio of highest eigenvalue and lowest eigenvalue is less than "1,000" and all conditional index values were less than "30" (App 1b). Thus, it was determined that there is no multicollinearity problem in our model.

4.3.2. The Results of MARS Method

MARS model provided 14 different models to us. The details of these models are emphasized on the table below.

Table 7: All Models Provided by MARS Method

Total Basis Functions	Total Variables	GCV	GCV R^2
10	4	0.035	0.630
9	4	0.016	0.831
8	4	0.011	0.879
7	3	0.009	0.901
****6**	**2**	**0.008**	**0.912**
5	2	0.009	0.908
4	2	0.013	0.866
3	2	0.016	0.831
2	2	0.016	0.833
1	1	0.032	0.659

Each row on this table represents different models. The model, which is at the bottom of the table, represents "starting model" whereas the model at the top refers to "the most complex model". On the other hand, MARS method defines "ideal model" by giving the sign of "**". As it can be seen, in our ideal model, there are 6 basis functions and 2 different independent variables. Another important point is that GCV value is the smallest and GCV R^2 value is the highest in the ideal model in comparison with other models. The details of this model are emphasized below.

Table 8: The Details of the Ideal Model

Variable	Coefficient	p Value
Constant	0.114	0.007
Basis Function 1	1.004	0.000
Basis Function 2	-0.660	0.000
Basis Function 3	0.191	0.000
Basis Function 4	-0.008	0.000
Basis Function 5	-0.071	0.000
Basis Function 6	0.027	0.000
F Test 178.54 [0.000] GCV 0.027 R^2 0.978 Adj R^2 0.973		

It can be understood from this table that p values of all basis functions are less than "0.05". This shows that all basis functions are statistically significant. Moreover, because F value is less than "0.05", it can be concluded that the model is also meaningful as a whole. In addition to them, the value of adjusted R^2 (0.973) indicates that independent variables can explain 97% of the dependent variable. In other words, it was defined that explanation levels of the model are very high. On the other hand, the details of the basis functions are explained on the following table.

Table 9: The Details of the Basis Functions in the Model

Basis Functions	Explanation	Coefficient
Basis Function 1	max (0, NPL - 0.060)	1.004
Basis Function 2	max (0, 0.060 - NPL)	-0.660
Basis Function 3	max (0, Bank Derivatives - 30)	0.191
Basis Function 4	max (0, 30 - Bank Derivatives)	-0.008
Basis Function 5	max (0, NPL – 0.190)*BF4	-0.071
Basis Function 6	max (0, 0.190 - NPL)*BF4	0.027

As a result, it was analyzed that two independent variables affect the mortgage crisis. Non-performing loans ratio is the first determinant which are stated in 4 different basis functions. Furthermore, the coefficient of basis function 1 is positive (1.004) and basis function 2 is negative (-0.660). In addition to this issue, this variable is positive in the first basis function and negative in the second basis function. When taking into the consideration of these factors, it was determined that there is a positive relationship between non-performing loans ratio and mortgage crisis. Higher NPL ratio decreases the profit of the banks. Due to this issue, banks become more reluctant to give loans. Owing to these reasons, the economy will go into the recession.

In addition to this aspect, it was also identified that bank derivatives also leads to this crisis. Similar to non-performing loans ratio, there is a direct relationship between the ratio bank derivatives/total loans and mortgage crisis. Before mortgage crisis, there was a significant increase in the amount of derivatives in comparison with total loans. Therefore, we can say that these derivatives were mainly done with speculative purposes instead of hedging purposes. In other words, it can be said that taking this high risk led to increase the level of mortgage crisis. Moreover, the relative variable importance of the variables is given below.

Table 10: Relative Variable Importance of the Variables

Variables	Cost of Omission	Importance (%)
NPL	0.083	100
Bank Derivatives	0.038	63.766

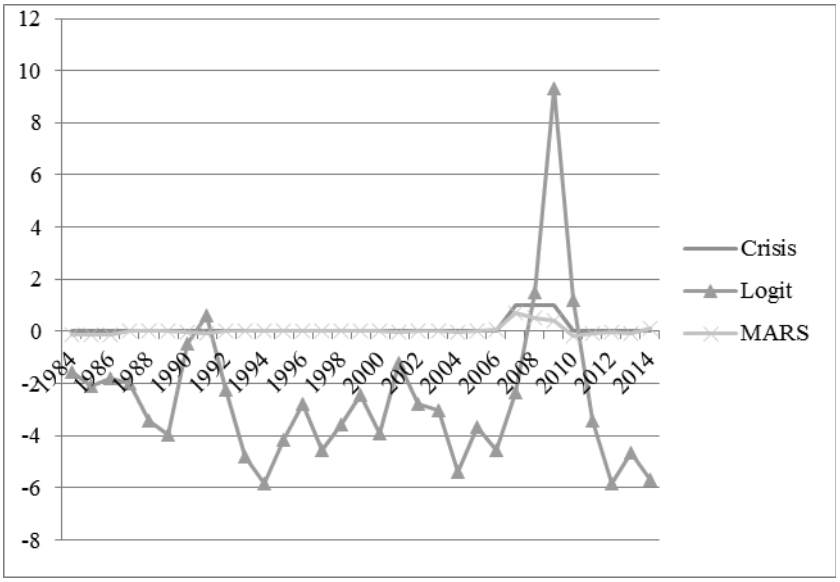
According to the results, it was seen that NPL is the most important variable in our model. It has a 100% importance in the model and 0.083 amount of cost in case of omission. Additionally, the variable of bank derivatives has a 63.7% importance levels. Other 12 variables do not have any importance in our study. In conclusion, the details of our model are given below.

$$Y = 0.114 + 1.004 * BF1 - 0.660 * BF2 + 0.191 * BF3 - 0.008 * BF4$$

$$- 0.071 * BF5 + 0.027 * BF6$$

4.3.3. The Comparison between the Results of Logit and MARS Methods

In this study, we made a comparison the results of logit and MARS methods. Within this scope, we compared the results of these two methods and the crisis. The results of this analysis are given on the following graph.



Graph 5: The Comparison between the Results of Logit and MARS with the Crisis

The graph above gives information about how logit and MARS methods are successful in order to predict the mortgage crisis. On this graph, the line, which has triangle symbol, represents logit results and the line that has cross symbol shows the MARS results. On the other hand, the line, which has no symbol, demonstrates the actual crisis. As it can be seen from the graph, the results of MARS model are similar to the actual crisis. That is to say, MARS model is more successful to define the reasons of the crisis than logit model.

Conclusion

We analyzed leading indicators of the global financial crisis occurred in USA in 2008. Within this context, 14 explanatory variables were used in order to define the reasons of this crisis. Furthermore, annual data for the periods between 1984 and 2014 was analyzed by using MARS and logit models so as to achieve this objective.

According to the results of logit model, it was determined that two explanatory variables are significant indicators of the mortgage crisis. First of all, it was defined that higher non-performing loans ratio is the main cause of this crisis. In addition to this situation, declining total assets of the banks is another indicator regarding logit model. The main reason is that when banks decrease the amount of the loans they give, this situation causes the economy go into the recession.

Additionally, with respect to the results of MARS model, two independent variables lead to the crisis. Similar to the results of the logit model, non-performing loans ratio is the most important leading indicator. Moreover, bank derivatives with speculative purposes are another cause of this crisis. Therefore, it can be said that taking high risk with derivatives led to increase the level of mortgage crisis.

Moreover, we also made a comparison between the results of logit and MARS methods. Within this scope, we compared the prediction of these two methods with actual crisis. As a result of this analysis, it was identified that MARS model is more successful than logit model in order to predict this crisis.

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Appendix 1: Multicollinearity Analysis of Logit Model

Appendix 1a: Collinearity Statistics

Independent Variable	Collinearity Statistics	
	Tolerance	VIF
Non-performing Loans	0.987	1.014
Total Assets	0.987	1.014

Appendix 1b: Collinearity Diagnostics

Dimension	Eigenvalue	Condition Index
1	1.115	1.000
2	0.885	1.123