

SPECIFICS OF THE APPLICATIONS OF MULTIPLE REGRESSION MODEL IN THE ANALYSES OF THE EFFECTS OF GLOBAL FINANCIAL CRISES

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Abstract

This paper aims to present the specifics of the application of multiple linear regression model. The economic (financial) crisis is analyzed in terms of gross domestic product which is in a function of the foreign trade balance (on one hand) and the credit cards, i.e. indebtedness of the population on this basis (on the other hand), in the USA (from 1999. to 2008). We used the extended application model which shows how the analyst should run the whole development process of regression model. This process began with simple statistical features and the application of regression procedures, and ended with residual analysis, intended for the study of compatibility of data and model settings. This paper also analyzes the values of some standard statistics used in the selection of appropriate regression model. Testing of the model is carried out with the use of the Statistics PASW 17 program.

Key words: *Multiple linear regression model, statistical tests, coefficient of determination, F schedule.*

1. THE SEPARATION OF THE REAL SECTOR AND THE FINANCIAL SECTOR

1.1. IDENTIFY AND ANALYZE CAUSES OF THE LAST ECONOMIC CRISIS ON A GLOBAL LEVEL

The starting point of our analysis is the assertion that the great economic crisis is caused by the separation of the real sector and the financial sector. First, we analyzed data from BEA agencies for the period from 1992 to 2008. These data show us that the U.S. international trade in goods recorded a negative sign from year to year, yet the international trade in services recorded a positive sign. This figure shows a decline in the real sector, on the other hand the growth of the service sector, in which we include the banking sector.

These data show us that at one point there was separation of real sector and the financial sector, which ultimately resulted in the emergence of the global crisis. In further analysis we come to the conclusion that the main culprits of the last crisis are American consumers who on average have 9 credit cards, so they repaid the loan from the first credit card with loan from another card, thereby making a vicious financial circle that eventually collapses like a house of cards.

The collapse comes at a time when funds remain fully captured in the financial sector. In fact, consumers at one moment are not using the money from credit cards to purchase goods, they are using them to cover the debt on credit cards. Reduction of purchasing goods causes reduction in demand of those goods (products). Decline in demand for products from the real sector has the causal effect on the reduction of production and therefore the emergence of high unemployment and reduce of the gross domestic product. Article concludes with what extent the reduction of export products from the real sector and balance on credit cards affect the movement of gross domestic product.

Possible development directions are related to making efficient management of the finance sector and limiting the numbers and opportunities of using credit on credit cards.

These directions lead us to the appearance of state intervention.

2. THE APPLICATION OF MULTIPLE REGRESSION PROCEDURES

2.1. ANALYSES OF THE EFFECTS OF GLOBAL FINANCIAL CRISES

Our application is based on analyses of the economic (financial) crisis in terms of gross domestic product as dependent variable, which is in a function of the foreign trade balance (on one hand) and the credit cards, i.e. indebtedness of the population on this basis (on the other hand), as independent variables, in the USA for the period from 1999 to 2008.

First, we analyzed BEA data for U. S. International Trade in Goods and Services for period from 1999 to 2008.

Here we can conclude that trade in goods has negative sign, which means that import of goods is bigger than exports of goods, and trade in services has positive sign, which means that export of services is bigger than import of services.

This led us to conclusion that there was a disturbance in the real sector. The real sector is the basis for economic development, so bearing this in mind, we continue with further analysis. The aim of further analysis is to determine why there was a growth of trade in services and decline of trade in goods. In further analyses we used data about consumer credit in the period from 1999 to 2008.

Table 1: U.S. International Trade in Goods and Services for period from 1999 to 2008.

(in millions of dollars)

Period	Balance		
	Trade	Goods	Services
	Annual		
1992	-39,212	-96,897	57,685
1993	-70,311	-132,451	62,141
1994	-98,493	-165,831	67,338
1995	-96,384	-174,170	77,786
1996	-104,065	-191,000	86,935
1997	-108,273	-198,428	90,155
1998	-166,140	-248,221	82,081
1999	-265,090	-347,819	82,729
2000	-379,835	-454,690	74,855
2001	-365,504	-429,898	64,393
2002	-421,601	-482,831	61,230
2003	-495,035	-549,012	53,977
2004	-609,987	-671,835	61,848
2005	-715,269	-790,851	75,582
2006	-760,359	-847,260	86,901
2007	-701,423	-830,992	129,569
2008	-695,937	-840,252	144,315

Source: The Bureau of Economic Analysis – BEA

Table 2: Consumer Credit: 1999 -2008

(in billions of dollars)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total	1,607*	1,741	1,892	2,000	2,104	2,219	2,314	2,418	2,551	2,702*

* Authors adjustments of data for 1999 and 2008 (adjustments are for analyses; other data are from Federal Reserve System)

Source: Board of Governors of the Federal Reserve System, 6th March 2008.

We used data from Eurostat, the Statistical Office of the European Commission, which give us percentage change of GDP volume for the United States in period from 1999 to 2008.

Business and economic analysis has certain unique characteristics in comparison with the analysis that is done in other disciplines. Multiple regression is a very important tool for economists. We begin with the implementation which illustrates an important task of regression model specifications. Model specification includes selection of exogenous variables and functional forms of models. The economic crisis is analyzed in terms of GDP (dependent variable, Y) which is in a function of the foreign trade balance (independent variable, X_1) and credit indebtedness of people in the U.S. (independent variable, X_2) for the period from 1999. to 2008.

Table 3: Growth rate of GDP volume – percentage of change on previous year

USA	Percentage change of GDP on previous year
1999	4,8
2000	4,1
2001	1,1
2002	1,8
2003	2,5
2004	3,6
2005	3,1
2006	2,7
2007	2,1
2008	0,4

Source: Eurostat, 2009.

From these data we can see decrease of GDP from year to year.

The analysis of defined problem and selection of variables define the specification of the model in general form:

$$(1) \quad \hat{Y} = b_0 + b_1X_1 + b_2X_2$$

The model specification strategy was

conditioned by the goals we want to achieve. One goal was to predict the dependent or output variable, GDP. Another objective was to assess the marginal effect of each independent variable. Marginal change is more difficult to assess because the independent variables are associated not only with the dependent variable but also with each other. If two or more independent variables change in mutual direct linear relationship, it is difficult to determine the individual effect of each independent variable on dependent variable. Now we will consider a multiple regression model in more detail.

The coefficients b_j represent the evaluation of the unknown parameters and they are derived based on the expressions below. The meaning of these coefficients is analogous to the meaning of the coefficients in the simple linear model. For example, coefficient b_0 indicates the expected values of dependant variable in the case where both independent values are equal zero, while coefficients b_1 and b_2 show average change of dependent variable (occurrence of Y) with the unit shift of one of the dependent variables, respectively.

Therefore, we have

$$(2) \quad b_0 = \bar{y} - b_1\bar{x}_1 - b_2\bar{x}_2$$

$$(3) \quad b_1 = \frac{\sum d_2^2 \sum d_1 d_y - \sum d_1 d_2 \sum d_2 d_y}{\sum d_1^2 \sum d_2^2 - (\sum d_1 d_2)^2}$$

$$(4) \quad b_2 = \frac{\sum d_1^2 \sum d_2 d_y - \sum d_1 d_2 \sum d_1 d_y}{\sum d_1^2 \sum d_2^2 - (\sum d_1 d_2)^2}$$

$$\begin{aligned}
 (5) \quad & d_1 = X_1 - \bar{X}_1 \\
 (6) \quad & d_2 = X_2 - \bar{X}_2 \\
 (7) \quad & d_y = Y - \bar{Y}
 \end{aligned}$$

Solving this model, we have:

$$\begin{aligned}
 b_0 &= 12,9449902842 \\
 b_1 &= 0,0000117775 \\
 b_2 &= -0,0077485802
 \end{aligned}$$

We obtain the following model

$$\hat{Y} = 12,945 + 0,0000118X_1 - 0,00775X_2.$$

Since coefficient b_0 indicates the expected value of the dependent variable in the case where both independent values are equal to zero, the value 12,945 indicates that the value of the dependent variable can be expected at this level with zero-level independent variables.

Value $b_1 = 0,0000117775$ indicates the average change (increase) in GDP when the foreign trade balance increases by the unit, provided that credit indebtedness remains unchanged (this is a direct relation between the dependent and independent variables). By analogy, $b_2 = -0,0077485802$ indicates the average change of GDP when credit indebtedness increases by the unit and the foreign trade balance remains constant (this is the inverse relation between the dependent and independent variables because the regression coefficient has a negative sign). Since the regression coefficients are absolute indicators, the phenomena included in the model are commonly reported in different measurement units, and it does not make sense to use them to compare their mutual influence of independent variables on the dependent variable. In the analysis we introduce the coefficient of multiple determination to explain the variation percentage of GDP, explained by the mutual influence of independent variables included in the model:

$$(8) \quad R_{Y/X_1, X_2}^2 = \frac{b_1 \cdot \sum d_1 d_y + b_2 \cdot \sum d_2 d_y}{\sum d_y^2} = 0,68.$$

The coefficient of multiple determination indicates that 68% of the variance of GDP is explained by the mutual influence of the foreign trade balance and credit indebtedness. What remains, i.e. 32 %, is the share of unexplained variability and shows the influence of those factors not included in the model. To use a previously shown regression equation for assessing and predicting the value of GDP, first we must test the significance of overall model. To test the validity of the model, we use the F schedule. As realized value $F = 7,34$ is greater than table value 3,74 (with a 5% risk, df: 2 and 14), we conclude that we should

reject the null hypothesis (that the foreign trade balance and credit indebtedness do not affect the GDP), i.e. that the model is adequate.

The second part of the paper is devoted to the analysis of the economic crisis in terms of GDP (the dependent variable, Y) which is in a function of the foreign trade balance (the independent variable, X_1) and the indebtedness of population of the United States on credit cards (as the most important part of the credit indebtedness of people from the first part of the analysis, the independent variable, X_2) for the period from 1999. to 2008.

Table 4: Foreign Trade balance and Credit Cards debt outstanding

Years	GDP (%)	Foreign Trade balance (import-export) in mil. \$	Indebtedness of the population on credit cards in billions \$
1999	4,8	265.090	651
2000	4,1	379.835	680
2001	1,1	365.504	711
2002	1,8	421.601	743
2003	2,5	495.035	776
2004	3,6	609.987	811
2005	3,1	715.269	847
2006	2,7	760.359	886
2007	2,1	701.423	925
2008	0,4	695.937	967
Total	26,2	5.410.040	7.997

Source: Eurostat 2009, The Bureau of Economic Analysis – BEA, The Nilson Report, Carpinteria, CA, Twice-monthly newsletter

We obtain the following model

$$\hat{Y} = 15,762 + 0,000011X_1 - 0,02392X_2$$

Now we can interpret the meaning of the coefficients. The coefficient b_0 shows that with zero-level independent variables the value of the dependent variable can be expected on the level of 15,762.

The value $b_1 = 0,00001101181$ indicates the average change (increase) in GDP when the foreign trade balance increases by the unit, provided that indebtedness of the population on credit cards remains unchanged (this is a direct relation between the dependent and independent variables).

By analogy, $b_2 = -0,0239180366$ indicates the average change of GDP when indebtedness of the population on credit cards increases by the unit and the foreign trade balance remains constant (it is the inverse relation between the dependent and independent variables because the regression coefficient has a negative sign).

In this case the coefficient of multiple determination is obtained in this way:

$$R_{Y/X_1X_2}^2 = \frac{b_1 \cdot \sum d_1 d_y + b_2 \cdot \sum d_2 d_y}{\sum d_y^2} = 0,584613 \quad .$$

The coefficient of multiple determination indicates that 58 % of the variance of GDP is explained by the mutual influence of the foreign trade balance and indebtedness of the population on credit cards. What remains, i.e. 42 %, is the share of unexplained variability and shows the influence of those factors that are not included in the model.

To test the validity of the model, we use the F schedule. As realized value $F = 4,93$ is greater than the table value 4,74 (with a 5% risk, df: 2 and 7), we conclude that we should reject the null hypothesis (that the foreign trade balance and indebtedness of the population on credit cards do not affect the GDP), i.e. that the model is adequate.

CONCLUSION

In this paper we have presented the necessary foundations for the application of multiple regression procedures. The aim is to identify and analyze causes of the last economic crisis on a global level, based on theoretical and methodological research, as well as their impact on the reduction of economic activities of modern economies.

The practical contribution of the paper is reflected in the creation of new empirical evidence which prove that the decrease of exports and excessive credit borrowing are the key driving factors causing last global crisis. Policy makers are to use our results to focus their activities in this direction.

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