Mykola Zhuk
Ivan Franko National University of Lʹviv

Valentyn Zdrok
Opiekun naukowy — Scientific Tutor

Econometric research of interdependence of major macroeconomic indicators of the Republic of Poland and indicators of the country's households

JEL classification: H31, E60, C01, C32, C90

Keywords: household, macro indicator, econometric model, system of simultaneous equations, imitational experiment

Słowa kluczowe: gospodarstwo domowe, makro wskaźnik, model ekonometryczny, system jednoczesnych równań, naśladowczy eksperyment

Abstract: The economic system of the Republic of Poland was studied with the use of econometric modeling. Simultaneous equation system model that describes interdependence of major macroeconomic indicators of Poland and its household's indicators was built. Several imitational experiments were made with the model to show the government's economic policy influence on the country's economic system.

Abstrakt: Zbadano ekonomiczny system gospodarczy Rzeczypospolitej Polskiej za pomocą modelowania ekonometrycznego. Model polskiej gospodarki zbudowano w formie układu jednoczesnych równań, opisujących relacje głównych wskaźników makroekonomicznych kraju i wskaźników polskich gospodarstw domowych. Dzięki imitacyjnym eksperymentom zbadano wpływ polityki gospodarczej rządu na system ekonomiczny kraju.

Introduction

The modern world is on the verge of fundamental changes in many areas of human activity. Problems that appear due to the transition to a new stage of development of society influence the everyday life of the planet. One of the main problems of the modern world is the uncertainty and lack of confidence in the effectiveness of the decisions made at the governmental level. We are often confronted with partially or completely incompetent decisions that were taken with the help of incomprehensible methods through which an entire nation is suffering,

Studenckie Prace Prawnicze, Administratywistyczne i Ekonomiczne 12, 2012

or even the neighboring countries that depend on their neighbors because of the globalization processes that actively increase today.

The main mission of the state leaders should be the prosperity of their countries and improvement of the living standards. The welfare of ordinary people largely depends on the labor market established in the country, the ease of doing business and the functioning of all parts of the economic system. We should not forget that the functioning of the economic system in the country is also very much dependent on the actions of every citizen of the country that is a member of the society. It is more convenient to consider the population of the country not as individuals but as a group of households that acquire new emergent properties due to synergistic effect.

The research on households plays an important role in the understanding of the development of modern economic processes at the macro level. At first glance, one household has no effect on the economy, but if we consider the aggregated set of all households in the country, together they play one of the most important roles in shaping the economic situation of the country. The main instrument of influence that households have on the economy is total consumption, which is the driving force of economic development as it creates a market for goods and services produced by enterprises which have the opportunity to develop and increase the country's GDP.

The object of research is the economic system of Poland. The essence of the research subject is to determine the main factors that can influence the possible development of the Polish economy in general and the major macro indicators in particular.

The main goal of the research is to study the relationships between unemployment, household consumption expenditures, consumer price index, gross domestic product, gross domestic savings, investment, gross debt and other macroeconomic indicators that are very important in forming the economic system of Poland.

The main tool in this research is econometric modeling.

1. Macroeconomic indicators which were used in modeling of the research object

To study the relationship between the main macro indicators of the Polish economic system we have used data (1990–2010) taken from the database of the World Bank, the online edition of "Economy Watch" as well as Internet sources www.reinhartandrogoff.com.

Econometric model, that is a system of simultaneous equations, consists of nine equations and therefore contains nine endogenous variables, which are presented in Table 1.

Table 1. Endogenous variables of the model

No	Variable name and unit of measurement	Designation of variables in the model
1.	Household consumption expenditure, mln USD	y_1
2.	Consumer price index (2005 = 100), %	y_2
3.	Domestic credit to private sector, % GDP	y_3
4.	Gross national income, mln USD	y_4
5.	Money and quasi-money (M2), % GDP	y_5
6.	Gross domestic savings, mln USD	y_6
7.	Investments, mln USD	y_7
8.	Unemployment, % of total labor force	y_8
9.	Stocks traded, mln USD	y_9

Table 2 contains the exogenous variables that were used in the model, there are only four of them.

Table 2. Exogenous variables of the model

No	Variable name and unit of measurement	Designation of variables in the model
1.	Trade, % GDP	x_1
2.	Gross domestic product, mln USD	x_2
3.	Total gross external debt, mln USD	x_3
4.	Gross national expenditure, mln USD	x_4

Household final consumption expenditure (formerly private consumption) is the market value of all goods and services, including durable products (such as cars, washing machines, and home computers), purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. It also includes payments and fees to governments to obtain permits and licenses. Here, household consumption expenditure includes the expenditures of nonprofit institutions serving households, even when reported separately by the country. This item also includes any statistical discrepancy in the use of resources relative to the supply of resources.[1]

[1] http://www.indexmundi.com/facts/poland/household-final-consumption-expenditure.

Domestic credit to private sector refers to financial resources provided to the private sector, e.g. through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment. For some countries these claims include credit to public enterprises.[2]

Money and quasi-money comprise the sum of currency outside banks, demand deposits other than those of the central government, and the time, savings, and foreign currency deposits of resident sectors other than the central government. This definition of money supply is frequently called M2; it corresponds to lines 34 and 35 in the International Monetary Fund's (IMF) International Financial Statistics (IFS).[3]

2. Construction of the Polish economy macroeconometric model

The general view of the model is the following:

(1) $y_{1t} = \beta_{10} + \beta_{12} y_{2t} + \beta_{14} y_{4t} + \varepsilon_{1t}$;
(2) $y_{2t} = \beta_{20} + \beta_{23} y_{3t} + \beta_{25} y_{5t} + \varepsilon_{2t}$;
(3) $y_{3t} = \beta_{30} + \beta_{38} y_{8t} + \gamma_{32} x_{2t} + \gamma_{33} x_{3t} + \varepsilon_{3t}$;
(4) $y_{4t} = \beta_{40} + \gamma_{42} x_{2t}$;$+ \gamma_{44} x_{4t} + \varepsilon_{4t}$;
(5) $y_{5t} = \beta_{50} + \beta_{54} y_{4t} + \gamma_{51} x_{1t} + \varepsilon_{5t}$;
(6) $y_{6t} = \beta_{60} + \beta_{64} y_{4t} + \beta_{69} y_{9t} + \varepsilon_{6t}$;
(7) $y_{7t} = \beta_{70} + \beta_{72} y_{2t} + \beta_{76} y_{6t} + \varepsilon_{7t}$;
(8) $y_{8t} = \beta_{80} + \beta_{81} y_{1t} + \beta_{85} y_{5t} + \beta_{87} y_{7t} + \gamma_{83} x_{3t} + \varepsilon_{8t}$;
(9) $y_{9t} = \beta_{90} + \beta_{97} y_{7t} + \gamma_{93} x_{3t} + \varepsilon_{9t}$.

Where β_{ij}, $i = \overline{1.9}$; $j = \overline{1.9}$ — unknown parameters near the endogenous variables; γ_{ij}, $i = \overline{1.9}$; $j = \overline{1.4}$ — unknown parameters near the exogenous variables; β_{i0}, $i = \overline{1.9}$ — independent parameters of equations; t — periods of time.

With the help of the order condition[4] we have found out that every equation of the model (1)–(9) is over-indentified. That is why the evaluation of model parameters was performed with the help of two-stage method of least squares.[5]

As a result of the estimation of parameters of the generalized model (1)–(9), we have received the following model:

(10) $y_{1t} = -4329.3753 + 157.9624 y_{2t} + 0.60495 y_{2t}$;
(11) $y_{2t} = -252.4365 - 5.5591 y_{3t} + 11.9438 y_{2t}$;
(12) $y_{3t} = 9.726 - 0.2747 y_{8t} + 0.00007 x_{2t} + 0.1282 x_{3t}$;
(13) $y_{4t} = 3880.8106 + 0.6227 x_{2t} + 0.3309 x_{4t}$;

[2] http://www.indexmundi.com/facts/poland/domestic-credit-to-private-sector.
[3] http://www.indexmundi.com/facts/indicators/FM.LBL.MQMY.GD.ZS/rankings.
[4] V. Zdrok and T. Lagotskyj, *Econometry: Textbook*, Kiev 2010, pp. 302–329.
[5] Ibid., pp. 330–349.

(14) $y_{5t} = 22.5623 + 0.000036y_{4t} + 0.1633x_{1t}$;
(15) $y_{6t} = 7750.0677 + 0.1092y_{4t} + 0.5214y_{9t}$;
(16) $y_{7t} = -3434.6963 + 113.268y_{2t} + 0.9996y_{6t}$;
(17) $y_{8t} = -54.436 - 0.00014y_{1t} + 2.7117y_{5t} - 0.00026y_{7t} - 0.1947x_{3t}$;
(18) $y_{8t} = -30888.5891 + 0.8039y_{7t} + 302.1346x_{3t}$.

3. Analysis of the model

Equation (10) describes the correlation of household consumption expenditures with the consumer price index and gross national income. The coefficient of multiple determination for this equation is 0.9986, which means that changes of the consumer price index and gross national income explain 99.86% of household consumption expenditures value variation.

The regression coefficients of the equation (10) can be interpreted as follows:

- the rise of the consumer price index value by 1% can increase the value of household consumption expenditures by 157.9624 mln USD, the result can be explained by the fact that Polish households would try not to reduce their usual level of consumption with the growth of prices;
- the rise of the gross national income value per year by 1 mln USD will increase the value of household consumption expenditures on average by 0.60495 mln USD.

Independent regression parameter of equation (10) shows the theoretical value of household consumption expenditures when exogenous variables: CPI and gross national income, have zero values. From an economic point of view this situation can be explained by the fact that this value of independent regression member in absolute value (4329.3753 mln USD) shows the level of household consumption expenditures that is needed to ensure a minimum level of vital functions. Note that the value of the independent regression member $|\beta_{10}| = 4329.3753$ of equation (10) is nominal, because this situation is only theoretical.

Equation (10) of the model was tested for adequacy with express diagnosis. The following null hypothesis was formulated: all multiple regression coefficients are zero. Alternative hypothesis: at least one of the multiple regression coefficients is different from zero. The critical Fisher criterion for equation (10) is $F^{cr} = 6.013$, and the empirical value of the criterion is $F^{em} = 6621.2261$. Since $F^{em} > F^{cr}$, equation (10) of our model is adequate with the probability of 99%.

Equation (11) describes the correlation of the consumer price index with the values of domestic credit to private sector and the money supply M2. Coefficient of determination for equation (11) is 0.913, which means that changes of the money supply M2 and domestic credit to private sector values explain 91.3% of consumer price index value variation.

The coefficients of the regression of equation (11) were interpreted as follows:

- increase of credits to private sector value by 1% of GDP will decrease the average value of consumer price index by 5.5591%, the decrease of consumer price index influenced by credits to private sector can be explained by the following, because of credits to private sector the production increases and this causes the level of consumer price index to decrease;
- increase of money and quasi-money (M2) value by 1% of GDP will increase the average value of consumer price index by 11.9438%, due to the increase of money amount that is not supported by growth of production, consumer price index increases too.

Express diagnosis showed that equation (11) is adequate with the probability of 99% by the Fisher criterion because $F^{em} > F^{cr}$ (94.503 > 6.013).

Equation (12) describes the correlational dependence of the credits to private sector value on unemployment rate, external debt and gross domestic product. Coefficient of determination for equation (12) is 0.9407, which means that changes of unemployment rate, external debt and gross domestic product explain 94.07% of credits to private sector value variation.

The coefficients of regression can be interpreted thus:

- growth of unemployment rate by 1% will decrease the value of credits to private sector on average by 0.2747% of GDP, this decrease can be easily explained since unemployed people do not usually receive credits;
- the rise of gross domestic product value by 1 mln USD will increase the value of credits to private sector by 70 USD;
- the increase of external debt value by 1% of GDP will increase the average value of credits to private sector by 0.1282% of GDP, since external debt includes all the economic areas and part of its value goes to banking sector making credits cheaper, we do not observe a significant increase in credits to private sector value.

Express diagnosis showed that equation (12) is adequate with the probability of 99% by the Fisher criterion because $F^{em} > F^{cr}$ (89.884 > 5.185).

Equation (13) describes the correlational dependence of gross national income value on gross national expenditures and gross domestic product. Coefficient of determination for equation (13) is 0.9998, which means that changes of external debt and gross domestic product explain 99.98% of gross national income value variation.

Interpretation of regression coefficients of equation (13):

- the rise of gross domestic product value by 1 mln USD will increase the value of gross national income in average by 0.6227 mln. USD;
- the rise of gross national expenditures value by 1 mln USD will increase the average value of gross national income by 0.3309 mln. USD.

Express diagnosis showed that equation (13) is adequate with the probability of 99% by the Fisher criterion because $F^{em} > F^{cr}$ (36278.83 > 6.013).

Equation (14) describes the influence of gross national income and trade on money and quasi-money (M2) value. Coefficient of determination for equation (14) is 0.8864, which means that changes of gross national income and trade explain 88.64% of money and quasi-money (M2) value variation.

Interpretation of regression coefficients of equation (14):

- the growth of gross national income value by 1 mln USD will increase the average value of money and quasi-money (M2) by 36 USD, the slight increase of money and quasi-money value can mean that increase of gross national income occurs in non-cash form;
- growth of trade value by 1% of GDP will increase the value of money and quasi-money (M2) by 0.1633 mln USD, this increase of money and quasi-money value can be connected with the increase in the amount of imported goods on national market since assurance of the normal turnover needs the money and quasi-money (M2) value to be increased.

Express diagnosis showed that equation (14) is adequate with the probability of 99% by the Fisher criterion because $F^{em} > F^{cr}$ (70.25 > 6.013).

Equation (15) describes the influence of gross national income and stocks traded on gross domestic savings value. Coefficient of determination for equation (15) is 0.9826, which means that changes of gross national income and stocks traded values explain 98.26% of gross domestic savings value variation.

The regression coefficients of equation (15) can be interpreted as follows:

- the growth of gross national income value by 1 mln USD will increase the average value of gross domestic savings by 0.1092 mln USD;
- the rise of stocks traded value by 1 mln USD will increase the average value of gross domestic savings by 0.5214 mln USD, therefore the development of stock market will increase the value of gross domestic savings.

Express diagnosis showed that equation (15) is adequate with the probability of 99%, since the Fisher criterion: $F^{em} > F^{cr}$ (509.46 > 6.013).

Equation (16) describes the influence of gross domestic savings and consumer price index on investments value. Coefficient of multiple determination for equation (16) is 0.9675, which means that changes of gross domestic savings and consumer price index values explain 96.75% of investments value variation.

The regression coefficients of the equation (16) can be interpreted as follows:

- the rise of consumer price index by 1% will increase the average value of investments by 113.268 mln USD, this increase might be connected with the growth of prices and also with psychological stimulation of investments, which is associated with an increase of the same price rise;
- the growth of gross domestic savings value by 1 mln USD will increase the average value of investments by 0.9996 mln USD, therefore the value of gross domestic savings plays an important role in investment process in the economic system of Poland.

Express diagnosis showed that equation (16) is adequate with the probability of 99%, since the Fisher criterion: $F^{em} > F^{cr}$ (268.28 > 6.013).

Equation (17) describes the influence of household consumption expenditure, money and quasi-money (M2), external debt and investments on unemployment rate. Coefficient of multiple determination for equation (17) is 0.5705, which means that changes of exogenous variables explain 57.05% of unemployment rate variation.

The regression coefficients of the equation (17) can be interpreted as follows:

- the growth of household consumption expenditures by 1 mln USD will decrease the value of unemployment rate by 0.00014%, which means that with the increase of richer households consumption expenditures, unemployment rate can be decreased;
- the rise of money and quasi-money (M2) value by 1% of GDP will increase the average value of unemployment rate by 2.7%, so this is very important to be remembered by the Central Bank while conducting monetary policy;
- the growth of investments value by 1 mln USD will reduce the level of unemployment rate by 0.00026%, therefore investments can be useful in overcoming the unemployment;
- the rise of external debt value by 1% of GDP will decrease the average value of unemployment rate by 0.1947%, therefore money involved activates processes that create new work places in an economic system.

Express diagnosis showed that equation (17) is adequate with the probability of 99% by the Fisher criterion because $F^{em} > F^{cr}$ (5.312 > 4.773).

Equation (18) describes the influence of investments and external debt on the value of traded stocks. Coefficient of multiple determination for equation (18) is 0.8901, which means that changes of exogenous variables explain 89.01% of traded stocks variation.

Interpretation of regression coefficients of equation (18):

- the increase in investments value by 1 mln USD will increase the total value of traded stocks by 0.8039 mln USD, so we can see that significant part of investments in Poland are made through the stock market;
- the growth of external debt value by 1% of GDP will increase the value of traded stocks by 302.1346 mln USD, which means that significant part of this money is used for investing and goes through the stock market.

Express diagnosis showed that equation (18) is adequate with the probability of 99% by the Fisher criterion because $F^{em} > F^{cr}$ (72.95 > 6.013).

4. Imitation of exogenous shocks

We have performed several imitational experiments with the help of the model (10)–(18). Note that the imitation process lies in the solution of simultaneous equation system (10)–(18). Results will be obtained when values of exogenous variables: trade, GDP, total gross external debt and gross national expenditures

are inserted and afterwards the solution of the system of nine equations and nine variables is found with the help of known algebraic methods.

First, we have run imitational experiment on the model (10)–(18) using real data of the Polish economy in 2010. Experimental results are given in Table 3.

Table 3. The results of imitation with real data from 2010

Macro indicator	Value
Household consumption expenditure, mln USD	288683.3
Consumer price index (2005 = 100), %	117.2553
Domestic credit to private sector, % GDP	47.13623
Gross national income, mln USD	453741.3
Money and quasi-money (M2), % GDP	52.89161
Gross domestic savings, mln USD	93642.21
Investments, mln USD	103451.3
Unemployment, % of total labor force	10.44635
Stocks traded, mln USD	69703.86

The next imitation shows what will happen to macro indicators when the government conducts fiscal policy of tight economy of national expenditures, setting them at the level of 10 billion USD. Other exogenous variables were left unchanged. Results are shown in Table 4.

Table 4. The imitational results of the fiscal policy of national expenditures tight economy

Macro indicator	Value
Household consumption expenditure, mln USD	187296.569
Consumer price index (2005 = 100), %	65.2595626
Domestic credit to private sector, % GDP	44.5767206
Gross national income, mln USD	299722.932
Money and quasi-money (M2), % GDP	47.3469507
Gross domestic savings, mln USD	60446.1422
Investments, mln USD	64379.0875
Unemployment, % of total labor force	19.7638274
Stocks traded, mln USD	38293.6906

As a result of this simulation, we saw that tight economy led to a decrease in the value of all macro indicators except from the unemployment rate, which rose from 10.44 to 19.76%, so the positive result of such actions was the reduction of the consumer price index value, but unemployment rate increased dramatically.

We have held another imitation of a situation completely opposite to the previous one, when the government decides to increase the size of the gross national expenditure to 90 billion USD. The results of this experiment are given in Table 5.

Table 5. The imitational results of a significant increase in national expenditures

Macro indicator	Value
Household consumption expenditure, mln USD	381159.872
Consumer price index (2005 = 100), %	164.681468
Domestic credit to private sector, % GDP	49.4708028
Gross national income, mln USD	594223.932
Money and quasi-money (M2), % GDP	57.9489867
Gross domestic savings, mln USD	123920.891
Investments, mln USD	139089.767
Unemployment, % of total labor force	1.9477294
Stocks traded, mln USD	98353.6059

As a result of this experiment, we can observe an almost complete overcoming of unemployment in the country, which fell to 1.95%, but at the same time there is a significant increase in the consumer price index value (164.68%), therefore the government should decide on the priority of the desirable results and choose what is more important for the country: to provide the highest possible level of employment or to stop inflation.

Conclusions

Application of the model is possible in predicting the values of household consumption expenditures, consumer price index, investments, unemployment and other important macro indicators in the short term. The model can also be used to study the impact of the fiscal policy on the behavior of households, the reaction of the labor market, stock market and other markets.

The proposed econometric model will help to understand better and to investigate the influence of macroeconomic indicators on the aggregated behavior of

households in Poland, which is a very important contribution to the study of the state problems at the macro level because households play an important role in the economic system.

The model can be improved by the use of gross domestic product indicator, not as an exogenous but as an endogenous variable, so the situation in the economic system will be described more adequately, although the model described above is very useful in studying the effects of governmental policy.

References

http://www.economywatch.com.
http://www.indexmundi.com.
http://www.reinhartandrogoff.com.
http://www.worldbank.org.
Zdrok V., Lagotskyj T., *Econometry: Textbook*, Kiev 2010, pp. 302–349.

Econometric research of interdependence of major macroeconomic indicators of the Republic of Poland and indicators of the country's households

Summary

The purpose of this article is to analyze the influence of the main macroeconomic indicators on unemployment rate. The author has built a macro econometric model of the Polish economic system. Several imitational experiments were made that showed the results of completely opposite fiscal policy examples and their influence on the listed macro indicators.