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Zvonko Merkaš
Davor Perkov
Petra Miličević

MANAGING MACROECONOMIC RISKS BY USING STATISTICAL SIMULATION

ABSTRACT: The paper analyzes the possibilities of using statistical simulation in the macroeconomic risks measurement. At the level of the whole world, macroeconomic risks are, due to the excessive imbalance, significantly increased. Using analytical statistical methods and Monte Carlo simulation, the authors interpret the collected data sets, compare and analyze them in order to mitigate potential risks. The empirical part of the study is a qualitative case study that uses statistical methods and Monte Carlo simulation for managing macroeconomic risks, which is the central theme of this work. Application of statistical simulation is necessary because the system, for which it is necessary to specify the model, is too complex for an analytical approach. The objective of the paper is to point out the previous need for consideration of significant macroeconomic risks, particularly in terms of the number of the unemployed in the society, the movement of gross domestic product and the country's credit rating, and the use of data previously processed by statistical methods, through statistical simulation, to analyze the existing model of managing the macroeconomic risks and suggest elements for a management model development that will allow, with the lowest possible probability and consequences, the emergence of the recent macroeconomic risks. The stochastic characteristics of the system, defined by random variables as input values defined by probability distributions, require the performance of a large number of iterations on which to record the output of the model and calculate the mathematical expectations. The paper expounds the basic procedures and techniques of discrete statistical simulation applied to systems that can be characterized by a number of events which represent a set of circumstances that have caused a change in the system's state and the possibility of its application in the field of assessment of macroeconomic risks. The method has no limitations. It can be used to study very complex systems by using special computer programs. The method uses reasonable estimates for important economic inputs to determine a set of results, not only one outcome at one point in time, yet there is a multiple-possibilities estimation of a certain risk performance, regarding the range of economic variables used in the model. Attempt to influence and influence itself on certain macroeconomic risks, in today's economy, occupies one of the primary imperatives of the world, therefore,

dr. sc. **Zvonko Merkaš**, *Libertas International University, Zagreb, Croatia* **e-mail:** zvonko.merkas@gmail.com

doc. dr. sc. **Davor Perkov**, *Libertas International University, Zagreb, Croatia* **e-mail:** dperkov@libertas.hr

Petra Miličević, *dipl. spec. oec., Libertas International University, Zagreb, Croatia* **e-mail:** petra.milicevic89@gmail.com

this paper deals with the mutual correlation and application of statistical simulations in macroeconomic risks measurement in order to better prevention and remediation.

KEY WORDS: macroeconomics, risk, statistical simulation, management, measurement

INTRODUCTION

At this point of development of the global economy "that characterizes the original uncertainty and utter unpredictability"[1] and in a situation when it is even more important in business "to embrace risk, rather than strive to destroy it"[2], managing macroeconomic risks is an area of intense scientific interest and a prerequisite of sustainability and competitiveness of the economy. As a result of globalization and market liberalization, the transition processes of accession to the European Union and global integrations, climate change, and increasing of the demands for quality standards[3], risk management at the macro level is becoming much more important, and the necessity of establishing an effective risk management at the national level is even more important for entrepreneurs and society as a whole.

The methods that are experimenting with the mathematical methods are called the simulated methods. Their objective is to explore the problem in the model for which we can't find an analytical solution, or it would be too difficult. Simulated methods have been developed as an alternative to the analytical methods, or as their competitors. Each one of them has its place and task, and in terms of their tasks they supplement each other. Some simulation models, primarily the use of Monte Carlo simulation, usually require correction of the results by using analytical methods. Simulation, meaning experimentation, presents the creation of possible solutions that are allowed. The number of possible solutions

is generally large in practice. When using the simulated techniques, the number of possibilities that will provide a representative solution needs to be chosen. In practice the following simulations are used: the combined simulation based on the use of all possibilities; statistical simulation where alternatives are selected using a statistical mechanism of random selection and heuristic simulation, in which the choice is made on the basis of rational choice.

Due to the large number and range of possible values of the input variables, the use of combined and heuristic simulation is not possible for the study the macroeconomic problems of the economy. The statistical simulation (e.g. Monte Carlo simulation) where the variables and variable values are selected based on statistical methods and mechanisms of random selection, enables the establishment of an appropriate model for managing macroeconomic risks. The paper will show a strategy for managing macroeconomic risks based on statistical simulation, while taking special care of making decisions based on uncertain sizes given to identify potential macroeconomic risks and the range in which the values of selected reference input variables can be expected, in order to act and identify potential causes of adverse events.

This paper differs from previous literature reviews because it is organized according to the issues involved in econometric techniques and case studies. Such an approach should encourage critical discussion when it comes to the use of econometric techniques in the assessment of economic growth.

RISK ANALYSIS

Methodological basis of the research is the decision theory in conditions of unsafe or risky business in the current macroeconomic conditions. To determine the dominant strategy or set of strategies for risk management it is necessary to create statistical stochastic simulation model. "The statistical simulation can be defined as the

use of the similarities to explore the characteristics of the actual system. The system displays a set of equations or parameters, a mathematical model is achieved by the similarity with the activities of the real system."[4]

Simulating can, due to its flexibility, classify complex relationships between the variables and thus mimic the actions of the real systems. Stochastic statistical simulating inserts randomly selected variables and relationships among variables (based on the probability distribution) to reflect the effect of uncertainty in the system. The purpose of the stochastic simulation is to determine the consequences of certain decisions and thereby facilitate business decision-making. Selection of risk management strategies in the model is limited by the available strategies in the market, where the emphasis will be placed on recent existing economic strategies that are implemented through fiscal and monetary policy. After the conducted simulation, the effectiveness of risk management strategies is examined by comparing the torque if the distribution (expectations and variance), the method of value at risk and / or methods of stochastic efficiency. Stochastic efficiency does not compare the results only after the calculated moments (mean and variance), but takes into account the overall distribution of the target, and includes preferences for risk. Prerequisite of the efficiency of the statistical simulation model is quality input data for a longer period of time in the observed area. Increasing levels of aggregation of data affects the generalization of the results.

MACROECONOMIC INDICATORS

The crisis of private debt originated from the United States in 2007 and expanded by the sale of uncertain claims of mortgage loans all over the world. The crisis was the result of the acceptance of over-indebtedness and greed as the normal state of the economy and furthermore,

we can define it as anthropological and ethical as well. Although the major economies recovered from the recession after a few years, the level of employment has not been reached yet and the exit from the crisis almost always results in a loss of jobs, compared with the time before the crisis, and with much lower rates of economic growth. In the Republic of Croatia, at the very beginning, the crisis has hidden structural economic and financial difficulties. As in greater parts of the business world, prudence and moderation were also missing here, and at one point too much risk in the economy was generally accepted. The expectations rose and the right to profits of 15 to 25% with the constant impoverishment of the middle class was legitimized.

Mishkin[5] defined the financial crisis as a disturbance in the market which is characterized by a sharp drop in the prices and assets and failures of the entire economy. Financial crises occur when there is a disorder that causes a rapidly increasing problem of the adverse selection and moral hazard in the financial markets, which are becoming unable to effectively transfer resources from those who save to those with the best productive investments opportunities.

Generally, there is cyclicality in the market economy. The so-called Junglar's[6] cycle has been appearing since the beginning of the market economy, usually lasting for periods of seven years and not always being equally expressed. Each cycle is different and flows differently through the economy. According to published data, in 2016 The Republic of Croatia was in the period of the cyclical increase in growth rates. However, in the serious analysis of the situation, it is necessary to look at the long-term growth trend and the factors that affect it.[7] The trend is the change of the growth rate of gross domestic product in the long run, after eliminating the influence of the cycle. The long-term growth rate of the GDP in the Republic of Croatia is 2%, and the "path of secular growth"[8] of course is not stable, there are breaks in trends, according to Bicanic.

Simply put, the cycles revolve around the trend. Because a certain cycle doesn't have to affect the trend itself, it is one of the reasons that one of the objectives of this research is to study the impact of macroeconomic measures on the trend, or the path of secular growth, and the impact of long-term growth rate on entrepreneurship.

As a response to the research question posed in this paper: what determines the growth trend of the economy and how it is possible to analyse it by various statistical methods and predict it by discrete statistical simulation, there are a variety of available databases[9] at disposal.

In addition to the available databases, the use of different econometric programs that are intensively used in this century is also relevant. Thus, the "growth regressions"[10] with the dependent variable (the rate of GDP growth) select several so-called independent "growth factors". It is estimated that well-chosen growth factors[11] explain the changes in the dependent variable. In this process, three problems[12] should be pointed out:

❧ rarely more than five variables have statistical sense,

❧ selected factors need to be quantified, which is generally very difficult,

❧ for the acceptable reliability of the results, there need to exist data for at least 15 years.

Consequently, we can determine the importance of the growth trend, because only by a long-term growth key, objectives of the economy can be achieved: an increase in domestic production, employment growth, and drop in unemployment, the relative decline in the debt burden, convergence with neighbouring countries and the reduction of social tension[13].

Gross domestic product

In 2003 the Croatian gross domestic product (GDP) was finally equalized with the one from 1990, just before the transition to the market economy. In the period from 2004 to 2008, GDP grew by a total of 23%. In the period of recession, from 2009 to 2012, the GDP dropped by 13%. In 2015, the gross domestic product amounted to just a bit under 44 billion EUR or 10.390 EUR per capita. In the first quarter of 2016 the GDP increased by 2.7% and expectations suggest that the growth of gross domestic product by the end of this year will be higher than 2%. The growth of GDP was also recorded in most other EU Member States on an annual basis, or more precisely, only GDP in Greece dropped[14] compared to the previous period. If the GDP is observed as a production flow, then it consists of individual and household consumption, gross investments, the government spending and net exports.

Employment and unemployment

Unemployment is one of the biggest problems of the Croatian economy. From the beginning of the nineties, unemployment constantly grew on an annual basis until March 2002, when the number of unemployed reached 415,000, and the unemployment rate stood at 24.1%. From that period to 2007, the unemployment rate dropped to 14.8%. From the beginning of the crisis in 2009 to 2013, 216,000 people lost their jobs, bringing the total number of unemployed to more than 365,000 people, and the unemployment rate reaching 20.2%. In May 2016, there were 232,327 unemployed or 14.4%, calculated by the new methodology. Although such employment trend carries positive and optimistic signs, the dynamics of positive changes is too slow, especially in the context of the EU average[15].

The unemployment rate in Croatia falls during the summer months and grows again during winter because of seasonal employments. Although currently (September 2016), the number of registered unemployed people is significantly below the levels of previous years, and the number of employed people is showing signs of stabilization, the state of the active population continues to dramatically decrease since it remains

under pressure from unfavourable demographic trends and economic emigration.

General government debt

According to the Croatian Chamber of Economy[16] at the end of the first quarter 2016 the level of public debt stood at 288.3 billion HRK. The share of public debt in the GDP ratio in the same period amounted to 85.8%. Indications of positive trends in the dynamics of public debt show that, in the continuation of economic growth, the objectives of the Convergence Program associated with stabilizing the public debt could be reached at the end of this year. But, at the same time, the growing risks of political instability and slowing down of the implementation of structural reforms also leave its impact, which means that in the rest of the year it will be even more challenging to impact on reducing the budget deficit and stabilization of the public debt, which also ultimately means the influence on the path of secular growth.

The convergence of the countries of the region and the country's credit rating

In times of crisis, the opacity of the market was also increased by risk assessment agencies, which advise and evaluate at the same time, and are often commissioned by those who they assess. Credit rating is defined as a set of properties of the loan seekers, such as position, assets, operations, and perspective, on the basis of which it is possible to make the assessment of its creditworthiness[17]. The fundamental task of the credit rating is the reduction of asymmetric information between investors and issuers of securities. Its role is important in economic policy, strategy policies and investment decisions, which is why in today's financial world it is almost impossible to borrow money on the capital market without a credit rating. In the last few years the demand for loans has risen dramatically because of the increasing number of countries and financial institutions

that borrow in the debt instruments market and the occurrence of a large number of credit derivatives and other financial products offered in these markets[18].

The consequence of the crisis is the knowledge that it is necessary to restore order in the economy and the market by prudent rules. Protection from the crisis and solidarity towards the weakest are required. Financial institutions must restore the role of the economy service, citizens, and public communities. In continuation, by the application of statistical simulations, we will try to assess the factors and establish which one has the greatest impact on the GDP growth rate. The econometric model's usage seeks to assess the factors affecting the changes in the credit ratings of developed markets and emerging markets. In these studies, a relatively small number of variables explain 90% of variation rating. The variables are GDP per capita, the rate of GDP growth, inflation, the ratio of foreign reserves and imports, the ratio of the current account balance and GDP, history of inability to settle liabilities and level of economic development.

THE APPLICATION OF THE DISCRETE STATISTICAL SIMULATION

The first results of econometric studies were based on cross-country regressions, where the dependent variable is the average growth rate of real GDP per capita in a given period, and the independent variables are different indicators of development of the financial system and the various control variables. Recently, panel analysis and time series analysis have dominated in econometric research. Beck[19] gives an overview of different econometric methodologies for evaluating the relationship between various factors and growth. In the regressions of growth more than hundreds of variables are used, but eight factors are the most commonly used and considered the most reliable[20]: the investment rate

CHART 1. THE MOVEMENT OF THE GDP GROWTH RATE FROM 2000 TO 2015[24]
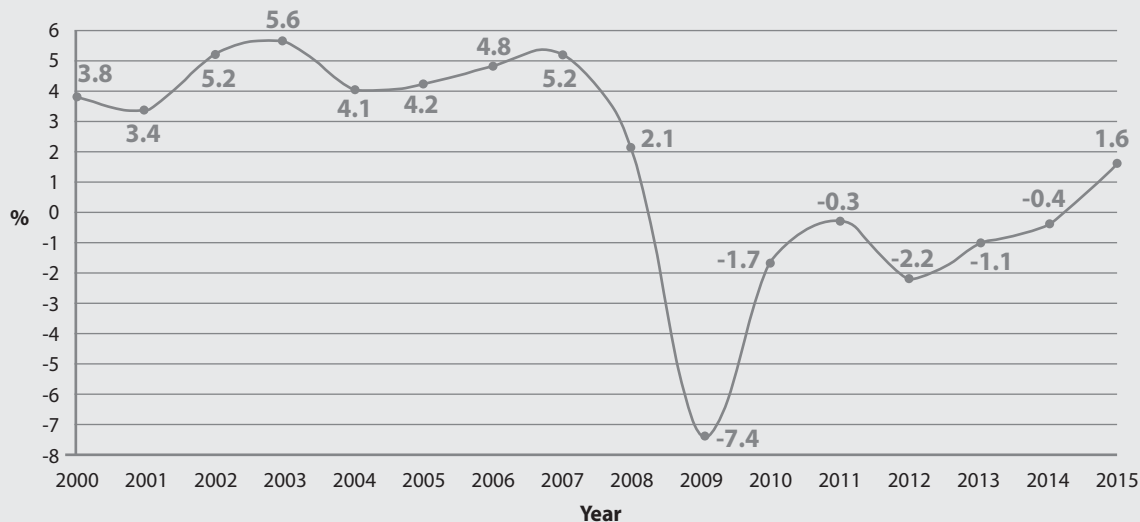
(the share of investments in the GDP), international trade (the sum of exports and imports in the GDP), the share of government expenditure (expenditure of the general state), the rate of population growth, economic inequality, human capital (investment in knowledge), competition and stability of the legal system. In Croatia, the average rate of investment in the last three years prior to the recession was 28.7%. The three-year average of the Croatian international exchange, before the recession, was 92.3%. The three-year average before the crisis Croatia kept government expenditure at 18.5% and did not deviate significantly from similar European countries[21]. Croatia has a negative population growth rate. The problem of aging is temporarily resolved by the immigration, but in Croatia, that figure is negligible.

It is believed that the high economic inequalities lower growth rate of the economy as they create political uncertainty, high pressures on the redistribution of water to a large and expensive state. The Croatian so-called Gini's coefficient for 2008 was 0.29 and is not included in the category of particularly high inequality. Recent research[22] shows that the estimated coefficient is often in the regressions with investments in the human capital negative, that greater investment in the "production" of human capital reduces the rate of growth and that the matter is not in expenditure in education but in the efficiency of investment. Croatia's temporary state is not that promising, there is an expensive and inefficient educational system and a low level of available human capital. In Croatia, the share of the state is great and there is an aversion to the entry of new capital. Abiding by contracts and an effective legal framework make up business activity prerequisites; however, it is notoriously true that Croatia "stands on weak legs" with regard to this matter.

Defining the input variables of the model

Monte Carlo simulation is a probabilistic computer algorithm in which the value of one or more random variables are selected by the density function, which

aims to predict all the possible outcomes of the process in which it is applied, and the probability of their occurrence. As such, the Monte Carlo method proves extremely useful in the decision-making process in terms of risk. The change of any element in a planned economic cycle affects the final result. One of the assessment methods of the change in the final result is the sensitivity analysis. The sensitivity analysis is often carried out through the analysis of extreme situations; the optimistic and pessimistic scenarios vary. The disadvantage of this method is the neglect of the case analysis in which input values select the value from the range between the least favourable and the most favourable one. The probability of a particular case is determined solely on the basis of appreciation.

In order to determine the path of secular growth from the above-mentioned data and the calculated regressions by applying discrete statistical simulation and by using calculated GDP growth rate average in past sixteen years, it is necessary to define input values in the model and generate the values from the least favourable and the most favourable, and process them by the Monte Carlo simulation. This technique consists of generating random numbers for each distribution which represent input variables and sequentially use the basic model to calculate the output variables. Thus, the probability for the values of the input variables affects the distribution of the results. The simulation will be carried out by using @RISK 7.5.[23] Palisade Corporation. After selecting the classical probability distributions of the critical variable of the project and generating a series of random numbers that correspond with the selected distribution, the result is displayed as a bar graph and a graph of the cumulative probability distribution of selected critical variables and their impact on the growth trend of the economy. The
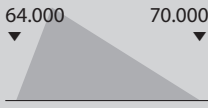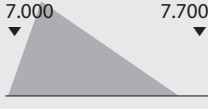
TABLE 1. GROSS DOMESTIC PRODUCT, ACCORDING TO EXPENDITURE APPROACH, REAL GROWTH RATES

	2015		2016	
	Q3	Q4	Q1	Q2
Non-seasonally adjusted data	**Compared to corresponding period of previous year**			
Final consumption expenditure	1.2	2.0	2.5	2.9
Households	1.4	2.4	3.1	3.0
Non-profit institutions serving households	2.0	2.1	2.1	1.8
General government	0.6	0.8	0.6	2.6
Gross fixed capital formation	2.2	3.7	4.3	6.3
Exports of goods and services	8.0	11.6	7.1	4.1
Exports of goods	10.9	14.4	9.4	6.6
Exports of services	5.7	8.5	4.6	1.6
Imports of goods and services	8.1	13.6	6.1	6.7
Imports of goods	8.6	13.5	6.4	7.6
Imports of services	5.6	14.1	4.5	2.2
Gross domestic product	2.8	1.9	2.7	2.8

Source: Croatian Bureau of Statistics, http://www.dzs.hr/default_e.htm, August 2016

TABLE 2. DEFINED VALUES OF THE INPUT VARIABLES

NO.	INPUT VARIABLE	DISTRIBUTION (MIL HRK)
1.	Final consumption expenditure	RiskTriang (64,498;65,595;69,981)
2.	Gross fixed capital formation	RiskTriang (7,029;7,149;7,627)
3.	Exports of goods and services	RiskTriang (61,482;62,527;66,708)
4.	Imports of goods and services	RiskTriang (41,353;42,056;44,868)

| NAME	CELL	GRAPH	FUNCTION
Final consumption expenditure	A1	64.000 70.000	RiskTriang (64498;65595;69981); RiskName ("Final consumption expenditure"); RiskCorrmat (NewMatrix1;1)
Gross fixed capital formation	A2	7.000 7.700	RiskTriang (7029;7149;7627); RiskName ("Gross fixed capital formation"); RiskCorrmat (NewMatrix1;2)
Exports of goods and services	A3	61.000 67.000	RiskTriang (61482;62527;66708); RiskName ("Exports of goods and services")
Imports of goods and services	A4	41.000 45.000	RiskTriang (41353;42056;44868); RiskName ("Imports of goods and services")

input variables: total consumption expenditure, gross fixed capital formation, export and import of goods and services (informative display of relative growth per quarter in Table 1), and as the output variable a determination is expected of the assumed value of the gross domestic product and the consequent impact on the trend of growth as well as the identification of the input variable that mostly affects the growth trend in the in order to determine the management strategy.

As Chart 1 shows, the largest growth rate in the past sixteen years was in 2003 and 2007, before the economic crisis occurred. In 2009, there was a great decline in the growth rate of more than 7%.

After 2009, the falling trend of gross domestic product continued, up to the last year, 2015, when the growth of 1.6%. The average growth rate of GDP in the last sixteen years is also calculated. By using measures of central tendency, the mean score was obtained. The average growth rate in the last sixteen years is 1.7%

The deterministic model is presented in Table 1, the calculation of GDP and its development is based on the methodology applied in the standard calculation according to the expenditure method. In the example, the simple triangular distribution, which is determined by three parameters: the minimum, maximum, and most likely superior

**CHART 2. MONTE CARLO SIMULATION GDP III QUARTER 2016**
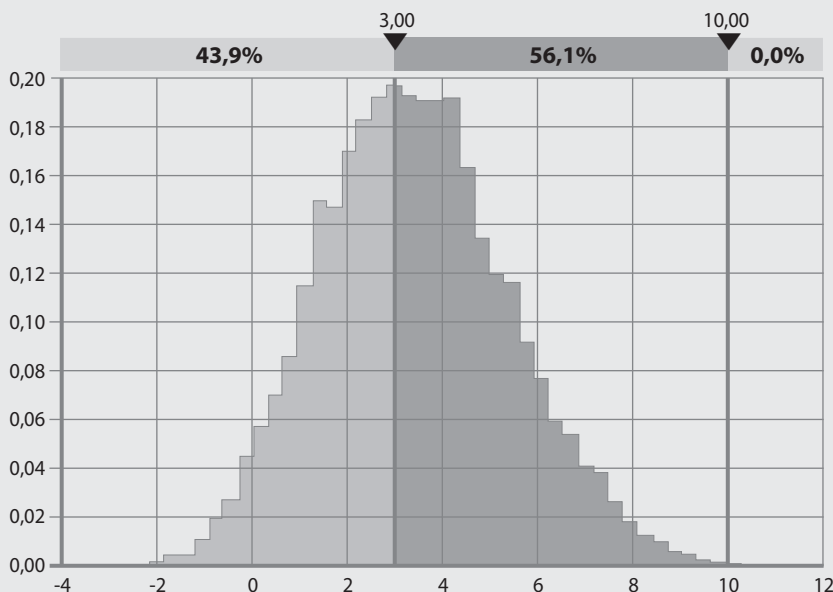
STATISTICS GRID	
CELL	**GDP III 2016 – ESTIMATION**
Minimum	-2,180
Maximum	10,289
Mean	3,401
90% CI	±0,0323
Mode	4,250
Median	3,328
Std Dev	1,965
Skewness	0,2041
Kurtosis	2,7801
Values	10000
Errors	0
Filtered	0
Left X	3,00
Left P	43,9%
Right X	10,00
Right P	100,0%
Dif. X	7,000
Dif. P	56,1%

CHART 3. THE CORRELATION OF INPUT VARIABLES ON THE OUTCOME

GDP III 2016 – ESTIMATION
Correlation Coefficients (Spearman Rank)
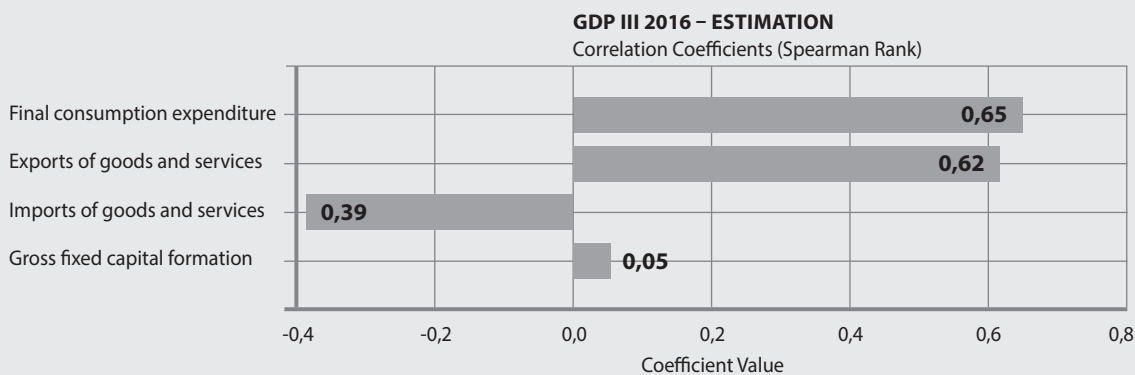
value, was used for the modelling of random variables. Parameter values were determined based on the study of economic movements in the past few years, the correlation values and the investment rate, international trade, the share of government expenditure, population growth rate, the existing economic inequalities, investment in knowledge, competition and stability of the legal system. As the minimum size equals to the realized value at the end of the same quarter from

the previous year, the expected or the most likely value is equal to minimum value increased by the average GDP growth rate in the last fifteen years in the third quarter, and the maximum value is the minimum value times the highest percentage of the GDP growth rate in that period.

Output size – define the output model

The output value is the estimate of GDP growth in the current quarter compared to the same quarter of the previous year. After 10,000 iterations, program calculated GDP growth by taking the value of inputs according to their probability of the range that we have determined by the triangular distribution. The program provides a variety of output information (Chart 2), obtained based on the frequency of certain values. The most important outputs are the image and the corresponding statistical report about the distribution of the output variable and graphs with data about the regression dependence of the output variable to the input variables and also about their correlation (Chart 3).

Analysis of simulation results

The most important moment in the creation of each model is to determine the frequency of certain values. The previous paragraphs in this paper presented the current macroeconomic situation and explained the correlation of input variables with the major macroeconomic indicators. Determination of the frequency of individual values was carried out in several attempts, and in early September 2016, the calculation of GDP growth in the next quarter was performed. The Monte Carlo simulation shows the probability of 56.1% that gross domestic product in the Republic of Croatia, based on defined values of the input variables, will be greater than 3% compared to the corresponding last year period. The expected GDP growth is 3.4%. The obtained data will be comparable with published data for

the third quarter of 2016 in late November 2016. Chart 2 shows the influence of the variables on the output. As expected, the export rate is negatively correlated to the GDP rate; nevertheless, the export and the final consumption rate have the greatest impact on the GDP rate.

CONCLUSION

The previous crisis, as a result of cyclical movement of the economy and various anti-crisis policies[25], strategic deregulation as well as globalization that led to the crisis, must pass through a critical sieve in order to be determined whether they create jobs of high purchasing power on profitable, socially and environmentally responsible grounds or not[26]. According to many authors, this is the only way out from the so-called virtual capitalism, which completely replaced, in economic terms, the real economy and management of national and international resources and their development.

Today, when globalization and market liberalization show their negative aspects, or in cases when they create favourable business opportunities, management of macroeconomic risks is an unavoidable part of the spectrum of sustainability, development and competitiveness of the economy. The created simulation model should help the discussion to facilitate economic entities to effectively manage global macroeconomic risks, using various strategies at the level of the economy, the achievement of better business results and stabilization operations in a multi-year period. Using optimal strategy affects the greater availability of financial resources by improving the country's credit rating, which affects the acceptance of new technologies, greater specialization and flexibility in managing the economy, and consequently, increases its competitiveness.

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