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A. Sholom
PhD in Economics, Senior Lecturer of the Department of Artur Golikov International Relations, V.N. Karazin Kharkiv National University
ORCID ID: 0000-0002-8471-5753
N. Kazakova
Phd in Geography, Associate Professor, Head of the Department of Artur Golikov International Relations, V.N. Karazin Kharkiv National University
ORCID ID: 0000-0002-4592-1466

MODELLING THE IMPACT OF THE STOCHASTIC EVENTS ON THE NATIONAL ECONOMIC DEVELOPMENT OF THE REPUBLIC OF MOZAMBIQUE

А. С. Шолом,
к. е. н., старший викладач кафедри міжнародних економічних відносин імені Артура Голікова, Харківський національний університет імені В.Н. Каразіна
Н. А. Казакова,
к. геогр. н., доцент, завідувач кафедри міжнародних економічних відносин імені Артура Голікова, Харківський національний університет імені В.Н. Каразіна

МОДЕЛЮВАННЯ ВПЛИВУ СТОХАСТИЧНИХ ПОДІЙ НА РОЗВИТОК НАЦІОНАЛЬНОЇ ЕКОНОМІКИ РЕСПУБЛІКИ МОЗАМБІК

Throughout the time that there are states, their economics have developed unevenly. There were always less developed states that today fall under the classification of periphery countries. The study of the dynamics of economic development involves the usage of specific methodology, in particular, the so-called dynamic approach. The article is concerned with the modeling the stochastic events as factors of economic development of the periphery countries, using the example of the Republic of Mozambique.

By studying the dynamics of economic development, we first of all investigate the quantitative and qualitative changes that take place in all structural elements of the economic system under the influence of a set of factors in order to obtain predictable results. It is not possible to determine the level and quality of such changes by using one single indicator, a whole series of indicators should be used.

The aim of the article is to model the impact of stochastic events as important factors in the country's development and build a macroeconomic model.

The article presents a dynamic macroeconomic model for determining impact of stochastic events on the national economy of peripheral countries on the basis of the GNU Octave 3.8 and regression and correlation analysis.
The dynamic macroeconomic model for the determining the impact of stochastic events on the national economy of the periphery countries was determined. Hansen's dynamic stochastic model, after adaptation and calibration, allows to investigate the effect of two correlated shocks, which together follow the process of autoregression of the first order. Such a model reflects the nature of the transformations and brings the model of the national economy of the Republic of Mozambique closer to the real world. The proposed calibrated model makes it possible to track trends and to perpetuate the behaviour of stochastic events, which allows to bring the economy to a new path of balanced development through adjusting the monetary and fiscal policies of the national economy. But the main advantage of the model lies in the fact that the impact of stochastic events, which is a negative factor for the development of the national economy, can be predicted in advance, while preserving the sustainable development of the national economy.

За весь час існування держав їх економіка розвивалася нерівномірно. Завжди були менш розвинені держави, які сьогодні підпадають під класифікацію периферійних країн. Вивчення динаміки економічного розвитку передбачає використання конкретної методології, зокрема, так званого динамічного підходу. Стаття присвячена моделюванню стохастичних подій як факторів економічного розвитку країн периферії на прикладі Республіки Мозамбік.
Вивчаючи динаміку економічного розвитку, ми перш за все досліджуємо кількісні та якісні зміни, що відбуваються у всіх структурних елементах економічної системи під впливом сукупності факторів, щоб отримати передбачувані результати. Неможливо визначити рівень та якість таких змін, використовуючи один єдиний показник, слід використовувати цілу серію показників.
Метою статті є моделювання впливу стохастичних подій як важливих факторів розвитку країни та побудова макроекономічної моделі.
У статті представлена динамічна макроекономічна модель для визначення впливу стохастичних подій на національну економіку периферійних країн на основі октави 3.8 GNU та регресійно-кореляційного аналізу.
Визначено динамічну макроекономічну модель для визначення впливу стохастичних подій на національну економіку країн периферії. Динамічна стохастична модель Хансена, після адаптації та калібрування, дозволяє дослідити ефект двох корельованих поштовхів, які в сукупності йдуть за процесом авторегресії першого порядку. Така модель відображає характер трансформацій та наближає модель національної економіки Республіки Мозамбік до реального світу. Запропонована калібрована модель дає змогу відстежувати тенденції та продовжувати поведінку стохастичних подій, що дозволяє вивести економіку на новий шлях збалансованого розвитку шляхом коригування монетарної та фіскальної політики національної економіки. Але головна перевага моделі полягає в тому, що вплив стохастичних подій, що є негативним фактором для розвитку національної економіки, можна передбачити заздалегідь, зберігаючи при цьому стійкий розвиток національної економіки.

Keywords: *stochastic events, national economy, factor of development, Republic of Mozambique.*

Ключові слова: *стохастичні події, національна економіка, фактор розвитку, Республіка Мозамбік.*

Problem setting. The Republic of Mozambique is the least developed country. It is at the end of the lists of countries by GDP, GNP, Human Development Index (HDI) and other indicators. A study of its national economy can provide key knowledge about avoiding mistakes and improving the overall economic situation of peripheral countries through realization of programs of sustainable development. However, even the programs of sustainable development do not exclude the possibility of sudden economic recessions, which naturally occur in the peripheral countries. They can be explained by stochastic events, the impact of which is modelled in this article.

Taking this into account, **the aim of the article** is to determine the impact of stochastic events on the Mozambique's economic development and build a macroeconomic model.

Literature review. The specifics of the source base are connected with its limited scope. Unlike, for example, the countries of Europe, the periphery countries do not provide so much statistical and factual material. M. Balsciar, R. Gupta and K. Kotzé (2017) forecasted South African macroeconomic variables with a dynamic stochastic model, as well as M. Berrocal – Costa Rican. But the degree of studying the peripheral countries, moreover the Republic of Mozambique, is rather low, the statistical material is available, but the lack of its projections, most researchers give priority to more advanced countries, leaving behind the periphery countries, e.g. the Republic of Mozambique. Dynamic stochastic models and their estimation is a subject of the research of such economists as H. Chen (2017), Ö. Dilaver, R. Calvert Jump, P. Levine (2018), J. Fernández-Villaverde, P. Guerrón-Quintana, J. Rubio-Ramírez (2015), A. Hansen, U. Wethal (2014), T. Harada (2018), T. Hassan, T. Mertens (2015), K. Judd, L. Maliar, S. Maliar, I. Tsener (2017), G. Kapetanios, S. Price, K. Theodoridis (2015), Y. Ma (2016), G. Mccandles (2008), J. Miao, P. Wang, Z. Xu (2015), D. Nachane (2017), C. Rogers (2018), C. Schoder (2017), H. Sieg (2016), K. West (2017), Y. Yu (2019).

Research methodology. The typical task of macroeconomic modelling begins with the description of all agents in the economy and their utility functions or optimization tasks. It is also necessary to describe all the budgetary constraints imposed on the agents. There are also assumptions about different markets and their imperfections. The model can contain a stochastic component in order to describe all structural shocks in the economy and how they affect different variables. At this stage, the task is to obtain a system of equations consisting of first-order conditions for optimization tasks of agents, balance equations, equilibrium conditions in all markets and equations that describe the dynamics of all shocks in the economy. This system of equations describes the dynamic dependencies between all macroscopic variables. Unfortunately, in most cases, we cannot solve this system of equations because of the following difficulties: first, the overwhelming number of equations is nonlinear, and secondly, many equations include conditional mathematical expectations for future values of variables. To solve the first complexity, most studies solve not the initial model, but its approximation, obtained as a result of log-linearization of equations around a stationary state. The problem of solving the system of rational expectations is very complicated. For some parameter values, the system has no solution, and in some cases, there are several solutions corresponding to several potential stationary states. The standard methodology is to limit the scope of the parameter definition only to those values, in which there is only the only solution to the linear system of expectations. The method is to minimize the distance between some empirically significant process characteristics evaluated on the data and obtained from the theoretical model.

In this article, the proposed dynamic macroeconomic model will be complicated by an autoregressive process in order to determine the present and future impact of stochastic events – shocks on the national economy, using the example of the Republic of Mozambique. The main model describing the stationary process is the autoregressive model with the delay order p in the form:

$$Y_t = a_0 + a_1 Y_t - 1 + a_2 Y_t - 2 + \cdots + a_p Y_{t-p} + \mathcal{E}_t \qquad (1)$$

In order to solve the model, we use of the Octave software platform (GNU Octave) for the computer. GNU Octave is a system for performing mathematical calculations that provides interpreted language that is largely compatible with Matlab. The TextWrangler interface was used to edit the code for the computer. This add-on is a simple, unique interface that provides a rich set of features for highly effective text and code editing, searching and transformation. The Dynare platform for the GNU Octave allowed us to process a wide range of economic models, including models of Dynamic Stochastic General Equilibrium (DSGE) and Generation Overlay Models (OLGs). Dynare's models include those that rely on the rational expectation hypothesis in which agents form their expectations about the future according to the model. But it can also handle models where expectations are shaped differently: on the one hand, models where agents can predict the future; on the other hand, models in which agents have limited rationality or imperfect knowledge of the state of the economy and, therefore, form their expectations in the learning process.

The simulation results of the model (i.e. national economy) in time are described on (Fig. 1) and (Fig. 2). Since the model is stochastic, during simulation it is possible to obtain numerically different results by manipulating the parameters and model output data.The simulation on the proposed graphs begins with the point of the "balanced development path", where all variables are proportional to the equations defined above. The charts below describe not the absolute values, but the dynamics of indicators, that is, are relative, but not absolute. Starting from left to right, the variables move to the new proportion of the "path of balanced development", reaching it in the right corner of the graph (in our case, t = 40).

Parameters after the start of the simulation, of course, do not change. The shock, which was designated by the Latin letter "lambda" (Fig. 1), models the negative changes in tangible capital.

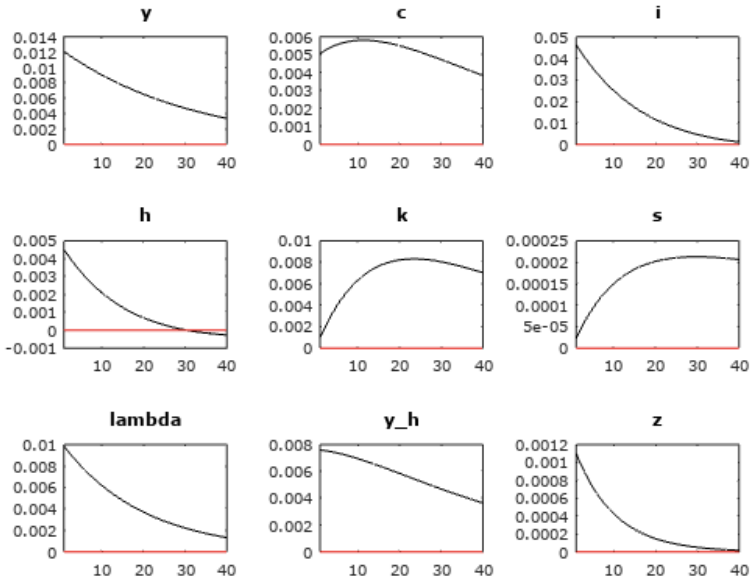

Fig. 1. The effect of the first shock of production. Made by the author on the basis of the proposed model
Source: autrors' own calculations on the basis of the proposed model.

The growth rates of production in the country have decreased, consumption has also fallen, but since it is not possible to significantly change consumption in poor countries (almost half of poverty), the compensation of a slight decline in consumption has become an absolute decline in domestic investment. A significant decline in production has caused a "boom of unemployment", which is very logical and has been observed in the Republic in recent years.

The capital ratio cannot be interpreted unless one recalls that it has two economic shocks at once, depending on their dynamics, we are able to observe both growth and fall. The dynamics of qualification development can also be explained only by means of Figire 2, where it is possible to observe a positive shock of changes in human resources. As for the three charts below: the effect of both shocks falls over time, and the productivity factor experienced a recession due to a deterioration in the state of capital. The effect of the negative shock of a lamb (for example, armed conflict) even exceeds the limits of the investigated period.

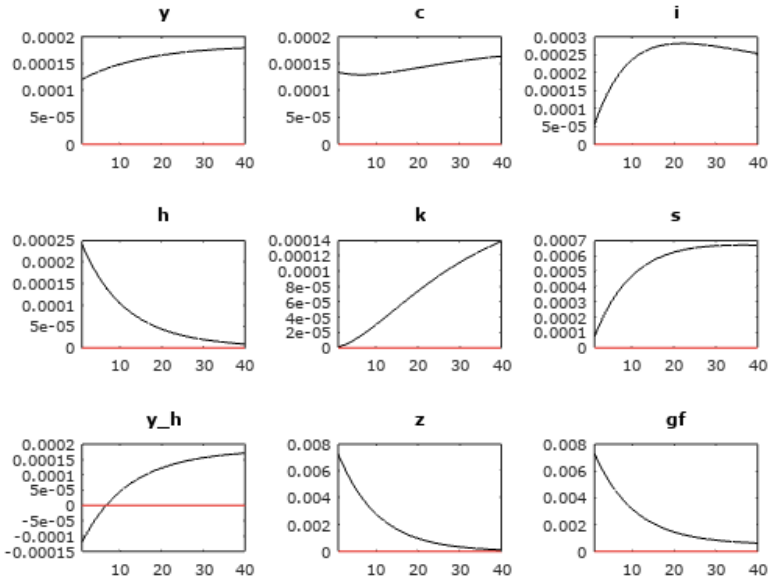

Fig.2. The effect of the second shock of production
Source: autrors' own calculations on the basis of the proposed model.

Figure 2 gives an opportunity to evaluate the changes caused by the second shock, this shock is positive, according to the graphs, it is possible to note that the qualification of the labor force increases during the first 30 periods, and the time spent on work - falls, this can be explained by the effect of the real the world as automation, that is, here it is necessary to consider the parameter s not as an increase in education, but as a favorable factor in increasing productivity, which is possible to observe in the first graph of the third line. The volume of investments begins to decrease after the 20th period, due to the fact that production capacities are now modified, and investors who were attracted or attracted by the attractiveness of a successful project immediately after the economic upswing gradually began to get out of interest. Their investments have been transformed from investment capital to material (graph in the middle of Fig. 2).

The cumulative effect of the transformations, however, is negative, it is possible to determine from the last graph, where the function of production has lost 3/4 of growth, that is, the country is experiencing a production crisis. In this simulation, the correlation coefficient of the standard deviation of autoregression of 0.85 was applied, that is, the rather high dependence of the mathematical deviation of the processes of economic transformation from each other.

Now it is proposed to consider the case where the correlation of the shocks is less, for example, 0.15 for the other parameter. It is important to note that the quantitative effect of the shocks did not undergo transformations, in order to make the comparison more vivid. In Figure 3 it is possible to assume that the changes occurred with the qualification variable and the effect of the second shock (because we reduced the correlation coefficient).

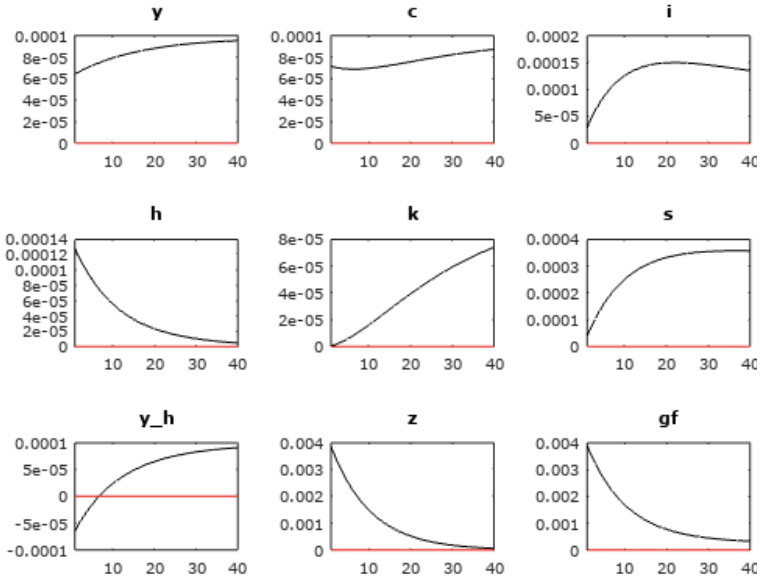

Fig. 3. The effect of the first shock of production (simulation with changed parameters)
Source: autrors' own calculations on the basis of the proposed model.

Unlike the first shock, the second (Fig. 4) caused serious transformations. All effects have the same tendency as during the first simulation, but the percentage change in transformations is less than two to three times in all cases. That is, we can conclude that the change in dependence shocks leads to a decrease in the magnitude of shock z.

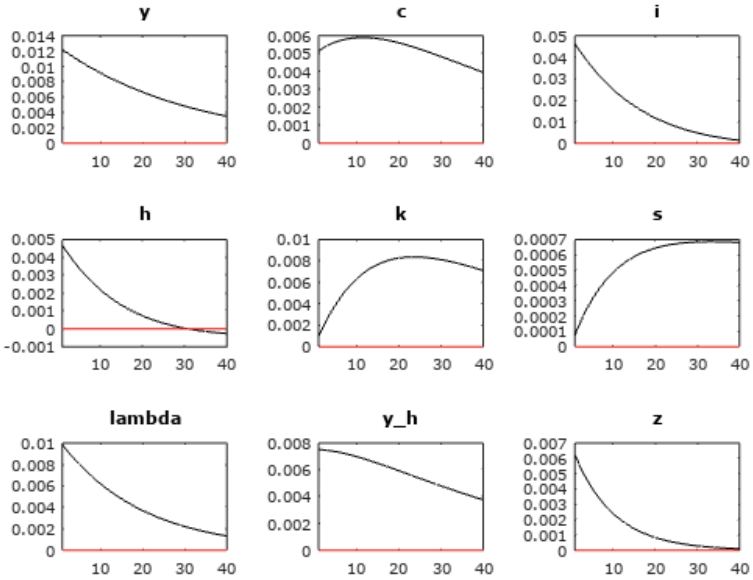

Fig. 4 The effect of the second shock of production (simulation with changed parameters)
Source: autrors' own calculations on the basis of the proposed model.

There are a number of possibilities for modifying the model. But making changes should be obeyed economic sense and reflect some of the changes that the agent wants to bring to the proposed model of the economy. For example, it is possible to change the parameters in the autoregressive process, simulating the growing dependence. In Mozambique, this would reflect the transboundations associated with the flood of the 2000s, when flooding directly affected production capacities: destroying infrastructure and agriculture. Or, on the contrary, reduce the correlation, connecting events that are indirectly related: the spontaneous involvement of the population in protests, mitigation, etc. during the election, and the number of enterprises, expressed in hours of work. It is recommended that such a simulation be performed during the next elections, because they reflect the greatest unstable nature of this kind.

From the broad interpretation of the results of real events in the Republic of Mozambique, it is possible to conclude that the proposed model can be used to approximate the simulation of perturbations of the national economy of the periphery countries.

Discussion. Globalization opens up the widest possibilities for truly global development, but the pace of its spread is uneven. The process of integration into the world economy is faster in some countries than in others. In countries that have managed to achieve integration, there are higher rates of growth and poverty reduction. The policy of external orientation has brought dynamism and prosperity to a large part of East Asia, completely changing the region that was 40 years ago among the poorest in the world. In turn, raising living standards has created opportunities for the development of democracy and advancement in the solution of such economic issues as environmental protection and improvement of working conditions.

In contrast, for many countries in Latin America and Africa, which carried out the policy of internal orientation in the 70's and 80's of the twentieth century, characterized by stagnation or a decline in the economy, increasing poverty and becoming the norm of high inflation. In many cases, especially in Africa, problems have increased due to the unfavorable development of external conditions. After these countries changed their policies, their income began to grow. At present, an important process of their transformation is taking place. It is necessary to help preserve this trend, rather than attempts to reverse it, and this will be the best way to promote economic growth, development and poverty reduction.

There are four aspects of globalization: trade, capital flows, labor migration, knowledge and technology transfer.

Trade. In general, Africa has poor results. Importance is also given to the export structure of countries. Significantly faster pace was the growth of exports of manufacturing products. The share of primary products in world exports (such as food and raw materials), the production of which is often engaged in the poorest countries, has declined.

Capital movement. Typically, this growth occurred after the period of a particularly pronounced "drying out" of these flows in the 80's. The structure of private flows has undergone radical changes. The most important category was foreign direct investment. Portfolio investment and bank loans also increased, however, they were characterized by greater volatility and dropped sharply after financial crises in the late 1990s.

Migration of labor force. Migration occurs mainly between developing countries. However, the influx of immigrants into advanced economies serves as a means of reducing the gap between salary levels in the world. This process

can also contribute to the reverse potential: the transfer of skills to developing countries and the increase of wages in these countries.

Distribution of knowledge and technologies. The exchange of information is an inalienable aspect of globalization, although it sometimes does not attract due attention. For example, direct foreign investment brings with it not only an increase in real capital funds, but also technical innovations. In a more general sense, the acquisition of knowledge of production methods, management techniques, export markets and economic policies requires very low costs, although such knowledge is an extremely valuable resource for developing countries.

During the twentieth century, the average per capita income in the world increased significantly, but this growth significantly differed from one country to another. Obviously, the gap in income levels between rich and poor countries has continued to increase for many decades. The latest edition of World Economic Outlook (World Economic Outlook) presents the results of the study of 42 countries (which have almost 90 percent of the world's population), which has data for the entire twentieth century. The conclusion is that although there has been a marked increase in per capita output, the distribution of income among the countries has become less uniform than at the beginning of the century.

However, income indicators do not give a complete picture of the real situation. If we take wider indicators of welfare that take into account social conditions, then the poorest countries will find significant progress. For example, such low-income countries, e.g. the Republic of Mozambique, achieved quite impressive results.

The unevenness of economic development is explained by a number of factors. That is, typically a recession (or decline) in the economy is due to the discrepancy between the level of development of the NTP, the extent of technical achievements and practical use (introduction into production, renewal of capital). But sometimes the recession may be caused by other factors of a stochastic nature, such as war, flood, social delusions, etc.

But are periodic crises an inevitable consequence of globalization? A series of crises in the 1990s - Mexico, Thailand, Indonesia, Korea, Russia and Brazil - was seen by some as evidence that financial crises are a direct and inevitable result of globalization. Indeed, in advanced economies, and in emerging markets, the issue of whether economic governance has become more complex as a result of globalization has become more and more difficult. The development of crises would take place quite differently, if there were no such openness to world capital markets. On the other hand, these countries could not achieve such a spectacular success in economic growth, if there were no such financial flows. These were complicated by the nature of the crisis, caused by the interaction of omissions in the national policy of countries with disadvantages of the international financial system. The governments of individual countries and the international community as a whole are now taking steps to reduce the risk of such crises in the future. That’s why stochastic events’ modelling is so important nowadays.

Conclusions. In the article the dynamic macroeconomic model was determined to study the impact of stochastic events on the national economy of peripheral countries. The proposed dynamic stochastic macroeconomic model, after adaptation and calibration, made it possible to investigate the effect of two correlated shocks that together follow the autoregression process of the first order on the national economy of the Republic of Mozambique. Such a model reflects the nature of the transformations and approximates the results to the real world.

A simulation of the movement of the national economy during the time was conducted. It gave permissible results regarding the effect of the permutations on the dynamics of the seven basic variables of the simulated economy: volumes production, volumes of consumption, volumes of investments, aggregate contribution labor, volumes of capital, skills development of labor force in time and productivity. From the proposed graphic material made using computer, to calculate the movement of the model in the study, it is possible to see that these two shocks have a different effect on processes, that is, they can describe more personalized overmutations than general-type models. The proposed calibrated model allows to track tendencies and permeate the behavior of stochastic events. The solution, calculated by the Dynare interface, is a unique optimization way, which is aimed at bringing the economy to a new path of balanced development. The proposed algorithm allows to improve predicts and provides data, after analysis, which may be certain recommendations for regulation of monetary and fiscal policy national economy. But the main advantage of the model lies in the fact that the impact of stochastic events that are a negative development factor for national economy, it is possible to predict and react in advance, preserving the sustainable development of the national economy. Further research should be concerned with the adapting and calibrating the proposed model, e.g. adding additional shocks, changing the correlation parameters of the autoregressive process, expanding influence options on the dynamics of macroeconomic indicators, etc.

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