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Economics

Probabilistic Approach to Economic Crisis Prognostication

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Abstract. This paper deals with the opportunity to predict economic crisis on the basis of a cybernetic approach using Bayesian methodology. The proposed approach shows a path of economic crisis prognostication that should be an essential tool for policy makers in order to avoid or to mitigate the consequences of a possible economic crisis. The method will be especially valuable for small countries with transient economy and businesses in order to create an optimal strategy of development during the crisis. A cybernetic model of economic systems and processes is developed. It is shown that the management of complex economic processes is qualitatively improved by a cybernetic approach if the factors affecting the economic system, including "noise", are correctly determined. The study presents a new understanding of the Bayesian methodology, which, together with the cybernetic structure, represents a stochastic model of the economic process. By estimating the probabilities of the factors (mainly economic indicators) constituting the model, it is possible to quantitatively determine the stability of the economic situation and, accordingly, to optimally manage the economic system. For this, it will be necessary to identify the factors affecting the system and causing its fluctuations, determine their a priori probabilities and conditional probabilities of the expected situation. Similarly, we can imagine political and other big systems where it would be possible to predict the expected fluctuations in the current situation by assessing the probabilities of expected changes in the factors affecting the system.

Keywords: stochastic modelling, cybernetic approach, Bayesian methodology, forecasting

Introduction

One of the decisive factors in the successful management of economic processes is an accurate forecasting of future events. The risk level, the future development of an economic events associated with uncertainty has considerably increased in recent decades. This was caused by different objective and subjective reasons, such as the changes in political geography of Europe and the emergence of the multipolar world order, the development of new information and communication technologies, the expansion and acceleration of tendencies of globalization, which allegedly creates prerequisites of equality of different people and countries, but actually aggravates the real conditions of many poorer countries, etc. The modern world is characterized, on the one hand, by the latest developments of political and economic thought. However, on the other hand, it is

characterized by political, financial and economic crisis and uncontrollable macroeconomic indicators and political processes despite the efforts of the world community, leading politicians and scientific and analytical centers of the world. Certainly, the prevention of undesirable phenomena and\or mitigation of their effects requires the development and implementation of effective forecasting methods on the basis of which effective management of economic or business situation will be possible.

The available methods of economic forecasting generally use the deterministic methods that were developed by Karl Marx [1,2]. These include business cycles analysis, for example, in the form of Kondratyev's waves [3] or the Z-score formula for predicting bankruptcy [4], etc. However, as a rule, everything is reduced to an incident explanation, and the attempt of forecasting of the future suffers failure. This is natural as real political and economic processes are stochastic, and such processes cannot be predicted with high accuracy by the deterministic methods based on "regularities" which are usually found on the observation of the latest events. Certainly, in special cases it is possible to obtain the satisfactory results of prognostication. For example, short-term micro forecasting of financial and economic indicators of the companies by using the quantitative methods of the analysis of temporary ranks yield quite acceptable results [5].

In some cases, based on the analysis of the political conjuncture, it is possible to predict the results of the electoral company in one or other country, etc. like Gallup, Inc., the Levada Center and other analytical companies do. But such processes belong to the so-called "predictable" phenomena. For multiple-factor and multidimensional nonstationary stochastic processes (what are economic processes), especially for the phenomena close to the type of "a black swan", the traditional methods of forecasting are of no use. It is also important to consider immigration and demographic trends, which often have a decisive impact not only on economic, but also on social and political stability [6].

This paper proposes a method of stochastic modeling based on a cybernetic approach for forecasting of complex economic processes, especially for crisis situations.

Cybernetic Understanding of Economic Systems and Processes

From a cybernetic perspective, the problem of forecasting economic processes, including risky and crisis situations, is the topic of management in the conditions of incomplete information [7]. In this case, it is possible to conduct the optimal management (i.e. to forecast risky and crisis situations and to make a relevant decision) on the basis of the analysis of the impacted factors, taking into account their probability characteristics (including the probability characteristics of "noise" – such as accidental events and factors, the uncertain influence of political and economic conditions and/or "shadow players").

Every sphere of human activity – whether politics, public administration, state governace, economics, environmental protection, or others – includes numerous factors. For effective management and forecasting, among multitude of factors, it is necessary to identify those that have a decisive, existential impact on the result of management and/or forecasting.

Understanding the vital importance of predicting or at least assessing the future development of the events, every decision-maker or top manager, whether a policy-maker or a businessman, must have the ability to analyze the existing information to construct practical and useful forecasts.

In a more or less stable political and economic situation in the country and in the world, forecastting is a relatively easy task. For example, the results of presidential or parliamentary elections in any country can be predicted at least approximately with the help of various studies, polls (unless, of course, there were gross research errors or there were no attempts to falsify both the polls and the voting process).

Similarly, in economics, it is possible to forecast future economic situation and such organizations as the IMF or the World Bank give acceptable recommendations on economic policy and strategy to many countries. It is much easier to forecast the results of companies' activities (profit, expenses, sales, etc.) based on well-developed marketing and business forecasting methods. Naturally, despite the apparent simplicity of the situation, a top manager, a decision-maker, must have the appropriate knowledge and outstanding abilities so that, together with the analysis of objective data, he could intuitively understand the general trend of development of economic and business processes.

However, the situation changes dramatically when the political, economic or social atmosphere in the world worsens. Suddenly, a global economic crisis occurs "out of the blue" as an unexpected attack on the world economy. Although, this phenomenon will most likely not be unexpected to well-informed individuals and organizations that monitor the slightest changes in the world and respond to its consequences in a timely manner. Most developed, rich and strong countries withstand this blow with minor losses. But for smaller and poorer countries, as well as companies, especially those with a weak financial position, the onset of the crisis is a sudden attack on the economic system, which more or less functioned and followed standard recommendations for forecasting and business planning. As a result, many companies declare bankruptcy, which entails various very unpleasant consequences – growth of inflation, unemployment, etc. and in some cases, this can develop into a political crisis.

It is almost impossible to determine the exact cause of a sudden economic crisis. As already noted, no one has succeeded in this yet. Only in general we can point to some objective reasons for economic development: overproduction, ignoring strict banking regulations, populist government decisions, fluctuations in prices for a number of basic products – oil, grain, sugar, gold, etc. In addition, so-called "shadow players" play a significant role in it, artificially stimulating crisis situations. Recently, the geopolitical claims of "global players" have proven to be extremely important. For example, Russia's military invasion of Ukraine. Obviously, political and economic consequences of this war are difficult to overestimate, although they could have been predicted in advance using the method discussed in this paper.

However, it is obvious that at least an attempt to forecast the consequences of global shocks will play a significant role in preparing a country (or at least individual sectors of the economy or companies) for possible crisis conditions. Those who listen to the relevant warnings will be able to develop new rescue strategies even if the exact characteristics (time, place, size, participants) of a possible crisis phenomenon are not known. A mere notice about possible shocks in the economic stability would be enough for creating a new alert behaviour of a company (a country) in order to continue activity with small losses.

In this paper, we consider the possibility of forecasting global crisis using cybernetic and probablistic approach. Such type of forecasting approach has to give an opportunity to the countries to avoid or to mitigate the consequences of the crisis, so to any type of organizations to create a new rescue strategy in the crisis conditions.

In this case, one can imagine the role of forecasting as being in the correct use of the results of probabilistic analysis of external and internal factors influencing the control object (in this case, the country's economy). In other words, it is macro and micro analysis of the economic environment, the existing strategy assessment and evaluation of the alternatives. Cybernetic approach shows the right way of the mentioned analysis. This approach can be used for any general case, including political systems or various types of organizations.

The cybernetic approach considers economic or political system/process or any type of organizations from the view point of the control theory. Forecasting is process of estimation of various events (i.e. crisis appearance) in unknown situations [9]. But, from

cybernetic point of view, crisis forecasting is topic of optimal control with incomplete information. So, it is possible to control the country's economy (i.e. to forecast crisis) on the basis of cybernetic approach. For this case, we need to know (or estimate) the probability characteristics of the factors, affected the country's economy, unpreditable events (such as "noise") and the consideration of feedback [8].

From the cybernetic point of view, the processes proceeding within a control object (economic or political system, country's economy, etc.) are unknown or little known for us. At our disposal there are external processes acting on the control object (denoted as *X*) and the reaction of the object, its response (denoted as *Y*). The purpose of optimal control is to make and to implement such decisions (controlling influence – denoted as *U*) that will give opportunities to achieve the aimed purpose taking in the account political/economic and social processes proceeding outside and inside the system (control object), and the influence of unpredictable events („noise"). Particularly, for the economic system, these factors are mostly the economic indicators, etc. [9].

To check how well we achieve the planned goals, the criteria for evaluating the decision must be correctly selected. In order to evaluate the quality of the purpose approaching we have to determine how effective are our decisions according to the selected criteria. After decisions realization testing it is important to analyze the feedback information. The decision should be corrected, changed or finally implemented according to feedback results. Maybe it is necessary to reconsider the criterion of optimality and the demands to entrance factors too. The criterion is strategic if it can change in compliance with changing circumstances.

The economic process, functioning of the country's (company's) economy is influenced by the national (local) and foreign political-economic circumstances as well. The character and intensity of the influence, the time and place of its appearance are not defined in advance, particularly under unstable political and economic conditions. Generally, such a situation occurs in developing countries of transitive economics. The nonprogrammable and unpredictable action of political-economic circumstances, as is customary, has an adverse impact on the functioning of the existing political system. Hence, the political-economic environment should be referred to „noise" from the standpoint of management. Using a feedback link, it is theoretically possible to predict the consequences of political-economic "noise" (including the influence of "shadow players") and the functioning of the system, and to choose an appropriate strategy. In the conditions of effective and viable public management, the feedback influences the economic system and forms various demands that finally stimulate the achievement of ultimate aims.

In case of correct definition of *X, U, Y factors* and *"noise"*, it is possible to estimate (i.e. to forecast) the probability of changes in any factors of the economic system. For this purpose, we use stochastic modeling.

Stochastic Model

Let event ***Y*** be the results of the economic system, e.g. the economic crisis of the world or of any particular country. Event *Y* may occur in different ways of X_i, $i=1,2,\ldots,n$. So we can introduce a conceptual model of the crisis as

$$Y = f(X_1, X_2, \ldots, X_n).$$

It is impossible even theoretically to construct a mathematical model *f* because of its stochastic character. The specific types of X_i depend on the type of event Y, the period of history and the interests of "shadow players". Today, for economic processes, they may be the tendencies of global and national economy; the trends of chief characteristics of the national economy and industry; the relations between national and global economy; the activity of huge transnational companies; the decrease in GDP; unbalanced budget; a failure of the pension system; revealed drawbacks of the

banking system; nervous behaviour of leading stock markets; aggressive political decisions; etc.

Say a priori probabilities $P(X_i)$ (the hypothesis about *Y* occurrence) are known. In this case, it is possible to investigate the changing process of $P(X_i)$ in accordance with the results of *Y,* i.e. after *Y* has taken place. For this purpose, we have to estimate *a posterior* probabilities $P(X_i|Y)$, which provide the basis for prediction of crisis events [10]. In accordance with Bayesian methodology, the conditional probabilities P(Xi|Y) can be estimated as follows [11]:

$$P(X_i|Y)= \frac{P(Xi) \times P\,(Y \mid Xi)}{P(Y)}.$$

The probability P(Y*)* should be evaluated by the formula of probabilities of full group

$$P(Y) = \sum_{i=1}^{n} P(Xi) \times P\,(Y \mid Xi).$$

The analysis of the above equations gives us the possibility to forecast the conditional probability of Y occurrence (i.e. the probability of crisis beginning) $P(X_i|Y)$ on the basis of a priori probabilities $P(X_i)$. It means that, during monitoring of the political and/or economic processes, it is possible to *note* the critical turning point of the conditions of origination of the crisis, i.e. to *note* the change in the value of probabilities $P(X_i/Y)$ i=1,2,…n, which should be considered as a sign of the crisis. So, the authorized persons/ structures can pay attention to the measures for reducing or mitigating of the crisis preconditions. For the practical use of the above-mentioned methodology, it is necessary to list and estimate the following:

- The ways of crisis occurrence – X_i;
- A priori probabilities $P(X_i)$;
- Conditional probabilities $P(Y|X_i)$.

For this purpose, it is necessary to use environmental scanning techniques that involves the study and interpretation of various processes and the factors of macro and miscro analysis. This is an attempt to look broadly at the world, international economic relations, political processes, etc. by well-known experts, politicians and professionals. The environmental scanning should be conducted by systematic monitoring and research of the current events, including qualitative, quantitative and judgemental (Delphi) methods (techniques). Although highly qualitative and subjective, the environmental scanning helps decision-makers to extend their view, to convert a current political/ economic situation into clear strategic vision and to think strategically about future developments in the surroundings.

Thus, if we manage to find the a priori probabilities of changes in the factors affecting the economic process $P(X_i)$, i=1,2,…,n (where n is the number of indicators under consideration) and the estimation of the conditional probabilities P(Yi|Xi) of the noise affecting the economic system, then it becomes possible to predict the stability of the economic situation.

Similarly, for multidimensional processes, by estimating the above a priori probabilities, it will be possible to predict the probability of an expected change (crisis) in the current economic situation. Obviously, the assessment of indicators of global economic processes will require the work of powerful scientific centers and the processing of a large amount of information.

However, this methodology can also be used by small and medium-sized businesses in a simplified form, monitoring only the indicators characteristic of their company.

Conclusion

The offered stochastic model gives an opportunity to evaluate the preconditions of the development of economic processes. On the basis of such an evaluation, the opportunity of predicting the future conditions of these processes arises. This does not mean that we can forecast particular events of economic processes, e.g. the economic crisis, but the prediction of the tendencies of changes in the world economic climate is possible. Understanding of the coming changes would be a sufficient condition for making the relevant recommendations for the countries in order to create the optimal strategy of development.

ეკონომიკა

ეკონომიკური კრიზისის პროგნოზირების ალბათური მიდგომა

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ნაშრომი ეხება ეკონომიკური კრიზისის პროგნოზირების შესაძლებლობას კიბერნეტიკური მიდგომის საფუძველზე ბაიესის მეთოდოლოგიის გამოყენებით, რომელიც უნდა იყოს აუცილებელი ინსტრუმენტი პოლიტიკის შემქმნელებისთვის, რათა თავიდან აიცილონ ან შეარბილონ ეკონომიკური კრიზისის შესაძლო შედეგები. მეთოდი განსაკუთრებით გამოსადეგია გარდამავალი ეკონომიკის მქონე მცირე ქვეყნებისა და ბიზნესკომპანიებისთვის, რათა შექმნან ოპტიმალური განვითარების სტრატეგია კრიზისის დროს. შემუშავებულია ეკონომიკური სისტემებისა და პროცესების კიბერნეტიკული მოდელი. ნაჩვენებია, რომ რთული ეკონომიკური პროცესების მართვა ხარისხობრივად უმჯობესდება კიბერნეტიკული მიდგომით, თუ სწორად არის განსაზღვრული ეკონომიკურ სისტემაზე მოქმედი ფაქტორები, მათ შორის „ხმაური". ნაშრომში მოცემულია ბაიესის მეთოდოლოგიის ახლებური გაგება, რომელიც კიბერნეტიკულ სტრუქტურასთან ერთად წარმოადგენს ეკონომიკური პროცესის სტოქასტურ მოდელს, რომლის შემადგენელი ფაქტორების (ძირითადად ეკონომიკური მაჩვენებლების) ალბათობების შეფასებით შესაძლებელია რაოდენობრივად განისაზღვროს ეკონომიკური ვითარების სტაბილურობა და, შესაბამისად, განხორციელდეს ეკონომიკური სისტემის ოპტიმალური მართვა. ამ მიზნით საჭირო იქნება სისტემაზე მოქმედი და მისი რყევების გამომწვევი ფაქტორების იდენტიფიცირება, მათი აპრიორული ალბათობებისა და მოსალოდნელი სიტუაციის პირობითი ალბათობების დადგენა. ანალოგიურად, შესაძლებელია წარმოვადგინოთ პოლიტიკური და სხვა დიდი სისტემები, სადაც შესაძლებელი იქნებოდა არსებული ვითარების მოსალოდნელი რყევების პროგნოზირება სისტემაზე მოქმედ ფაქტორებში მოსალოდნელი ცვლილებების ალბათობათა შეფასებით.

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