Graph Analytics for Digital Economy Tasks

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Abstract. The manuscript discusses theoretical and practical examples of the use of graph analytics to solve the priority tasks of the digital economy, as the first stage of the knowledge economy. First, authors outline a simulation model which can be used to track fluctuations in inflation. Since a rise in inflation can reflect the rise in prices of goods and services, and how consumers lose ground as their earnings buy fewer goods, predicting inflation – and its effects – can be of great importance. The model presented is based on the cognitive graph. The cognitive graph has 15 vertices which are factors impacting the economy. The bonds between the vertices are analyzed and the incidence matrix is formed. Next, unbalanced cycles whose length is more than 2 are recognized in the graph. It is these unbalanced cycles that typically cause inflation, and the detriment to the economy. This model makes possible the examination of 5 unbalanced cycles, and its use allows the government (decision-makers) to implement to control and limit inflation's effects on the economy. The theoretical basis applications of cognitive graphs for the quantitative assessment of knowledge are also presented.

Keywords: digital economy, knowledge economy, inflation; simulation modeling; cognitive graph; graph analytics; consumer price index; key rate.

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1. Introduction

The one of the most challenging problems in the economy is to estimate the inflation fluctuations in separate industries, since it is inflation that determines the conditions for business and social welfare. An approach of solving this problem, presented in this paper, is based on simulation modeling, in particular, on the cognitive graph analysis that allows revealing the correlation between impact factors and economy's strength.

The cognitive graphs used to model economic process have been analyzed in [1-5]. Much attention was paid to the modeling of inflation processes in the studies [6-8]. However, the model proposed in this research takes into account great outliers. For example, the lockdowns in the course of the pandemic are regarded as an economic factor.

The goal of the research is to elaborate the forecast model of inflation and to determine the possible measures aimed at controlling and limiting inflation's effects on the economy.

To resolve the imposed task, a prediction model for inflation dynamics is built in several steps: a cognitive graph with 15 vertices, which are the economic factors, is designed; next, the bonds between the factors are described; after that, the incidence matrix is formed and the unbalanced cycles whose length is more than two are plotted on the graph. It is these unbalanced cycles that typically cause detriment to the economy. This model makes it possible to find

and examine five unbalanced cycles, therefore, its use allows the government (decision-makers) to implement active measures against inflation's effects on the economy.

At the level of tasks of the digital economy, as the first stage of the knowledge economy, the theoretical foundations for the use of graphs for the quantitative assessment of knowledge are proposed.

2. Materials and Methods

The growing volume of analyzed data needs new mathematical models of different systems to decrease material and time costs spent during the studies [9]. Each method of the mathematical modeling has its own specific. One can classify the modeling methods as follows: econometric modeling, machine learning models, simulation modeling [10].

The economic researches are based on the data used in machine learning models [11]. Such models can be created if the stable trend of historical data is available [12].

Well-structured economic data also allow building classical econometric models. Data completeness and reliability are critically important in description of evolutionary development of economic process [13].

However, sometimes the evolutionary development stops, and the dynamic processes are initiated by the subjects' instant actions, which previously were not implemented, or by the political decisions, the reactions on which could not be predicted in advance. In other words, such situations are regarded as outliers and it is rather difficult to elaborate robust statistical methods for them [14, 15].

In this case, the proper analysis approach is to design scenarios and to consider all reserves which belong to economic subjects and which are used as protective measures of subjects' reaction. In this paper, the reserves are regarded as a set of the elaborated actions provided with material resources, and prepared as the measures to manage risks.

The problem of econometric models is the emergence of "revolutionary moments", i.e. the moments when evolutionary development, which potentially can be predicted by models, is no longer evolutional since development becomes a complex of unpredictable reactions of the subjects to environment impacts [16]. The reasons of that can be political decisions or changes of reaction to the events. It is likely that the nature of interaction between subjects underlies these events [17].

The simplest example of the interaction between two subjects is the "coevolution" model, called so by biologists. As it can be understood from the name, the evolution of one species impacts the evolution of another species, that, in its turn, influences on the evolution of the first one. For instance, Lotka-Volterra "predator-prey" model forecasts that the growth of predator population causes decrease of preys. At the same time, if the number of preys falls, the population of predators falls too, that is explained by shortage of food supply. The model has the following differential equation:

$$\frac{dx}{dt} = (\alpha - \beta y)x,$$
$$\frac{dy}{dt} = (-\gamma + \delta x)y,$$

where x – number of preys, y – number of predators, t – time, α,β,γ,δ=$const$ – coefficients that characterize relations between populations of predators and preys [18].

To use econometric models for solving such problems is not efficient. In reality, observing the fact (number of preys or predators) we can "catch" the moments (values of temporal series) when the dynamics direction changes [19]. Today, in the contemporary world, it is unwise to assume the existence of isolation factors, but the more irrational decision is to neglect the factors which can arise at certain moments or, alternatively, stop impacting. Even if we correctly determine the range of historical data, we cannot be sure that at a certain moment a new character of interactions would not be "switched on" or "switched off" causing unstable condition of the system [17].

Sometimes we cannot apply the models which are based on the principles of the theory of probability as they allow estimating only specific dependencies between random variables. In case when one of the factors cannot be defined by measurable function (for example, it is a result of adoption political decisions and it is just a parameter of controlling social and economic system), all models become possible for implementation only if a decision-maker understands this aspect [20].

Machine learning models are less subjected to critics of mathematical methods, since they reflect the situation "as is". However, training the models

requires huge number of datasets and a great deal of time which is not always possible [21, 22].

At the first stage, one needs to determine the factors impacting the state of the studied system. Inner factors of the system are divided into two classes: target and off-target. Outer factors (or control factors) are the indicators which are artificially introduced into the system by the decision-maker to obtain the specified state of the model [11].

At the second stage, the bonds between factors are built. That means it is necessary to determine the character and strength of the bonds between one vertex and other graph vertices. It is obvious that maximum quantity of such bonds will be (n(n-1))/2, where n – number of factors of the studied model [23].

The next stage is the assignment of action force of the source-factor on the resulting factor to each bond. Three main approaches exist:

- analytic, based on expert opinion of specialists in the given area;
- statistic, based on statistic approach, which classical tool is correlation;
- statistic expert approach [24].

Each of these approaches has both advantages and drawbacks. For example, analytic approach can be highly difficult applied in models with numerous factors of high order. Statistic approach, for its part, traditionally faces the serious problem concerning unstructured data base of the bonds between factors (data inconsistency, irregularity), that results in difficulties arising in calculation of bond strength. Thus, the third method is considered to be the optimal one as it is the synergy of the first and the latter [25].

If a model is built not on numeric data but on analytical ones, impact bonds of one factor on another show only positive/negative influence of the first factor on the second one. In this case, numeric characteristics of the bonds are equal to +1 and -1 respectively. That will be the signed graph [26].

Further, on the basis of obtained data, a weighted cognitive graph is to be built. Its vertices are the mentioned above factors, its edges are the bonds between factors and the weights of these edges are numeric features of the impacts between the factors [27].

Now we consider the term *balanced model*. Let G = (V, E) be a cognitive graph describing the system. Fig. 1 shows an example of a cognitive graph. Let us suppose that there is at least one cycle of length n≥2. Then if $\prod_i sgn(w_{i\,i+1}) = 1$, where i=0,…,n-1, the cycle is called balanced. Otherwise, if $\prod_i sgn(w_{i\,i+1}) = -1$, the cycle is called unbalanced [28]. The model will be balanced unless all graph cycles describing this model are balanced.

Balance of the graph influences on stability of the model in mid-term and long-term forecast. Being stable in a short period, if unbalanced cycles present, in long term period the model behavior will not be consistent. To provide steady state for the system, one can apply control action by which system perturbations are regulated and, thus, to balance the graph [16].

To determine the presence of the cycles of length k in the graph with n vertices, it is necessary to make an absolute incidence matrix A. To determine which vertices are the vertices of the cycle of length k, one needs to determine nonzero diagonal elements of matrix A^k [29]. These nonzero elements will indicate the participation of the vertex in the cycle of the length k. For example, diagonal vector of the matrix A^2 will be (1, 2, 1, 0). The vector of diagonal elements of matrix A^3 is equal to (2, 1, 2, 1). It is clear that if the cycle of the length n exists, all diagonal values of the matrix A^n must be different from zero. Since diagonal values of the matrix A^4arrange the vector (3, 5, 3, 1), the cycle of the maximum length exists.

Thus, the present graph possesses the following cycles:

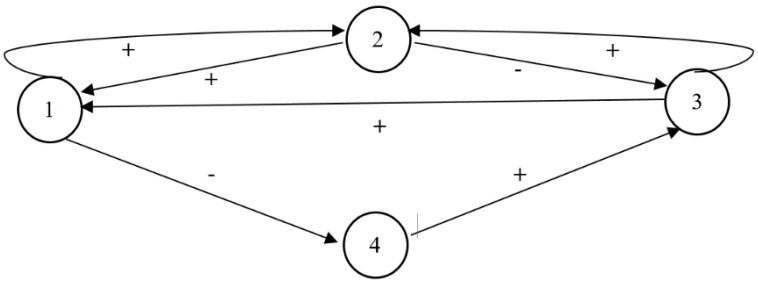


Fig. 1. Example of a cognitive graph

- of length 2: (1) $\overset{+}{\rightarrow}$ (2) $\overset{+}{\rightarrow}$ (1) – balanced cycle; (2) $\overset{-}{\rightarrow}$ (3) $\overset{+}{\rightarrow}$ (2) – unbalanced cycle;
- of length 3: (1) $\overset{-}{\rightarrow}$ (4) $\overset{+}{\rightarrow}$ (3) $\overset{+}{\rightarrow}$ (1) – unbalanced cycle; (1) $\overset{+}{\rightarrow}$ (2) $\overset{-}{\rightarrow}$ (3) $\overset{+}{\rightarrow}$ (1) – unbalanced cycle;
- of length 4: (1) $\overset{-}{\rightarrow}$ (4) $\overset{+}{\rightarrow}$ (3) $\overset{+}{\rightarrow}$ (2) $\overset{+}{\rightarrow}$ (1) – unbalanced cycle of maximum length.

This example does not clearly demonstrate the necessity to apply method of cycle search by raising matrix A to certain power. However, the more vertices, i.e. the factors of the systems, graph possesses, the easier procedure of cycle search becomes. Since the modeled system, as a rule, have at least the second order of quantity of factors, the given algorithm is applicable.

In this example, it is the prevalent unbalanced cycles that have great impact on the system. Unbalanced effect means that there is a cyclical nature in the structure of analyzed system: like in the Lotka-Volterra model [29], which is described by unbalanced cycle of length 2, it is very difficult to evaluate dynamics of population development as the model is cyclic. If one deals with such graph, reflecting the analyzed model, it is necessary to introduce controlling actions which change the character of the bond between model factors to bring the system into steady state. That will make it possible to apply econometric methods for further forecasting dynamics of system development.

If the model possesses unessential disbalances, which do not impact on target factors, such parameters can be considered as “blank noise”. Additional controlling actions are often expensive and time-consuming, and their contribution to the system structure is small. Hence, it is important to determine which of unbalanced cycles have significant effect on the system and to focus on bringing these cycles to balanced state.

Knowledge and its quantitative measurement, information

Little attention was paid to knowledge and its quantitative measurement. Much more involved in information, its transmission, quantitative measurement. This was largely due to the technology of information transmission, the emergence and development of cybernetics. In this regard, we note N. Wiener with his book "Cybernetics", the Hungarian mathematician A. Renyi, the winner of the Eduard Rhein Prize in 1999 V.A. Kotelnikov with his pioneering publication of the "sampling" theorem, which became known as the Wittker-Kotelnikov-Shannon theorem and which marked the beginning of the development of the digital economy. This topic became especially popular after the publication of the works of S. Shannon. The first systematic research in the field of knowledge economics was carried out in the 1960s by Fritz Machlup, a professor at the University of Vienna, who used the concepts of knowledge and information as full synonyms. However, with the advent of the "knowledge economy" in science, there was a need for a theoretical understanding of the very concept of "knowledge", the possibility of its quantitative measurement.

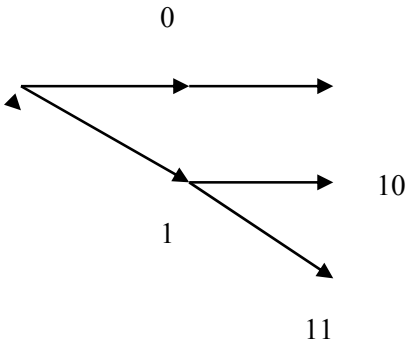
Labyrinth task

Consider a oriented graph. Suppose someone goes along this graph (in the direction of the arrows) from left to right, deciding at each fork in which direction to go. In this regard, we introduce the following axiom:

Axiom

Suppose that a question is asked, to which only answers “yes” or “no” are possible and they are equally likely. Then the answer to this question contains an elementary amount of knowledge -1 bit.

Turning again to the graph, we note that the knowledge of the correct path (for example, about the passage of the entire graph or about the passage to its end, somehow indicated) contains as many bits of knowledge as there are forks in this path. This knowledge can, for example, be sold to someone who wants to buy it (let's imagine that this graph is a labyrinth and the correct path is the path to the exit from this labyrinth).



So, we propose to measure the amount (volume) of knowledge by the number of equiprobable answers "yes", "no".

So, in the well-known algorithm for searching for a person (successive division of a group in half), this algorithm for a group of 2^n people allows you to extract bits of information or knowledge

Note that if the specified specific answers are not equally likely, then the knowledge in the answer will be less than 1 bit. There are games that are not quite for children, which adults also play. For example, Renyi, in his already cited book, describes such a game called "Bar-Kokhba". In this game, one participant thinks of something, for example, some phrase. The other participant must guess the riddle. He is allowed to ask simple questions that allow only “yes” and “no” answers. The stated point of view on knowledge and its quantitative measurement is indirectly confirmed by the fact that the level of knowledge, a person's experience is often assessed by the ability to give meaningful answers to the questions asked.

Note that in our opinion, any research and scientific work is quite similar to the above-mentioned Bar-Kokhba game or a labyrinth problem, only in scientific work it is not always clear where the exit is and what it is.

In concluding this paragraph, let us challenge some of the judgments about knowledge made at different times by different people. The idea expressed earlier that knowledge should be clear, but information is not obliged, and an example is given with learning to ride a bicycle. They say that any story about how to ride a bike is fuzzy and does not help the student. But this example is not convincing. Also not convincing are the considerations that knowledge must be true, while information can be false. Therefore, we believe that these two concepts: knowledge and information are very difficult to distinguish; research and the search for new approaches in this direction should be continued.

3. Result: a Forecast Model of Inflation Dynamics

One of the main tasks of the Central Bank of the Russian Federation is the inflation targeting. Being the key indicator of the health and stability of the economy, the inflation reflects regular trend of price increase for goods and services and it is equal to the ratio of item of goods/service price in the present period to the according price in the previous period. The period depends on the basis respect to which the inflation is calculated (week, month, quarter, year inflation) [30].

Accordingly, the inflation in country is calculated for the set of goods and services. Formula for calculating the consumer price index (CPI) is

$$I_P = \frac{\sum Q_i^0 P_i^t}{\sum Q_i^0 P_i^0} \times 100\%,$$

where t – present period, 0 – base period, Q_i and P_i – amount and price of the goods respectively. It is evident that the dramatic change of prices for any constituent of CPI may have a significant impact on the result, especially if we consider the effect of low base (in case when core inflation is not high). Thus, considerable inflation changes of some goods and services may have a profound effect on the average inflation in the country [31].

Since one of the important leverages to regulate inflation is the state monetary policy (SMP), the main tool of which is a key interest rate, the inflation dynamics directly affects the population of the country. The change of the key interest rate also directly affects the change of crediting rate for citizens or business as well as investment of funds [32].

Our goal is to analyze the inflation forecast model and to determine potential controlling actions in order to mitigate inflation fluctuations on the generalized example in the industry in which price per cent rise fast outrun the average historical one. As it was mentioned earlier, to make the inflation dynamics predictable, it is important to have such constituents of food basket that would not have large price outshoots.

Noticeable changes in some industries could be observed during pandemic. For instance, the dramatic inflation rise was caused by demand inflation rise as well as supply inflation rise. Since the Central Bank launched soft monetary policy to increase monetary supply and to stimulate local economy, interest rates were at remarkably low level at the beginning of the pandemic. That favored formation of low basis effect and one could witness that during economic recovering the influence of some industries on the integrate inflation indicator was higher than the usual one (for example, automotive and construction industries, some food products). This atypical inflation in single industries resulted

in rapid growth of the total inflation and later that strongly affected the Central Bank's decisions which concerned welfare of the citizens.

We introduce some assumptions to build the model to forecast emergence of inflation disbalances on the generalized example of one industry:

1. Forecast model is a short term;

2. We will assume that the key interest rate $R_{nominal} = Rreal+E[I]$, where R_{real} – a real target interest rate, and $E[I]$ – expected inflation. We are interested in inflation surges which are different from expected inflation;

3. Prices of goods are given in local currency;

4. The model is general: some bonds between the model factors can be corrected in dependence on the industry.

A set of graph vertices, corresponding to the factors of the system, is as follows:

V_1 – The change in the worldwide prices for goods denominated in local currency;

V_2 – The cost of the local currency against the currencies of the main trade partners;

V_3 – The change in the worldwide prices for constituent parts of goods for the final product;

V_4 – Government grants/reduced-rate lending for population and corporations;

V_5 – Growth rate of the real local inflation;

V_6 – The change of demand level on the domestic market and as a result:

product deficit; information support of the demand for a product; acquisition of expensive tangible assets as an investment method; change of population preferences – migration to the lower cost category of the goods.

V_7 – The change in the level of fiscal stimulation: modification of taxes, tariffs, budget expenses on infrastructure projects and population support;

V_8 – Activities of Federal Antitrust Authority;

V_9 – A part of import equipment used in manufacture (in monetary terms);

V_{10} – A part of export-worthy products;

V_{11} – Probability of price fixing arranged by companies:

- model "monopolistic competition", demand is elastic. Price fixing is arranged between all participants of the market;
- model "oligopoly", demand is not elastic. Price fixing arranged between all participants is the result of increased prices of one company.

V_{12} – Increase of production costs;

V_{13} – Impose of lockdown;

V_{14} – The reaction of the population to imposed restrictions (instant increase of demand for basic need goods and essential commodities as a result of panic);

V_{15} – The reaction of the government aimed at controlling population panic (information via news channels).

The Fig. 2 demonstrates the generalized industry model.

Now we describe the bonds between the factors of the given system:

$V_1 \overrightarrow{+} V_3$: when the worldwide costs of raw materials increase , it is obvious that the constituent parts of a product used in production on the local market reflect worldwide cost dynamics;

$V_1 \overrightarrow{+} V_9$: when the cost of imported products rises, the demand for it falls and the companies start buying equipment on domestic market;

$V_1 \overrightarrow{+} V_{10}$: the increase of worldwide prices motivates the companies to grow the export share as sales of product become more profitable and the operation profit margin rises;

$V_1 \overrightarrow{+} V_{11}$: the increase of worldwide prices leads to high probability of cartel agreements between the companies which are out of the competiveness to establish the specified prices on the local market;

$V_1 \overrightarrow{+} V_{12}$: the increase of the cost of the equipment and raw materials leads to the increase of the production costs;

$V_2 \overrightarrow{-} V_1$: strengthening of the local currency results in decrease of prices of world goods (denominated in foreign currency) in local currency;

$V_2 \overrightarrow{-} V_5$: strengthening of the local currency results in decrease of prices of imported products, all that decreases the general price level in economy. The effect of transferring currency exchange rate on inflation in short term period is considered to be less than the one in long term period;

$V_2 \overrightarrow{+} V_9$: in the course of strengthening the local currency, the foreign equipment price (denominated in foreign currency) obviously falls, that will cause increased demand for import.

$V_2 \overrightarrow{-} V_{10}$: strengthening of the local currency results in the situation when the exporting companies loose interest to trading on the international markets due to more stable local market;

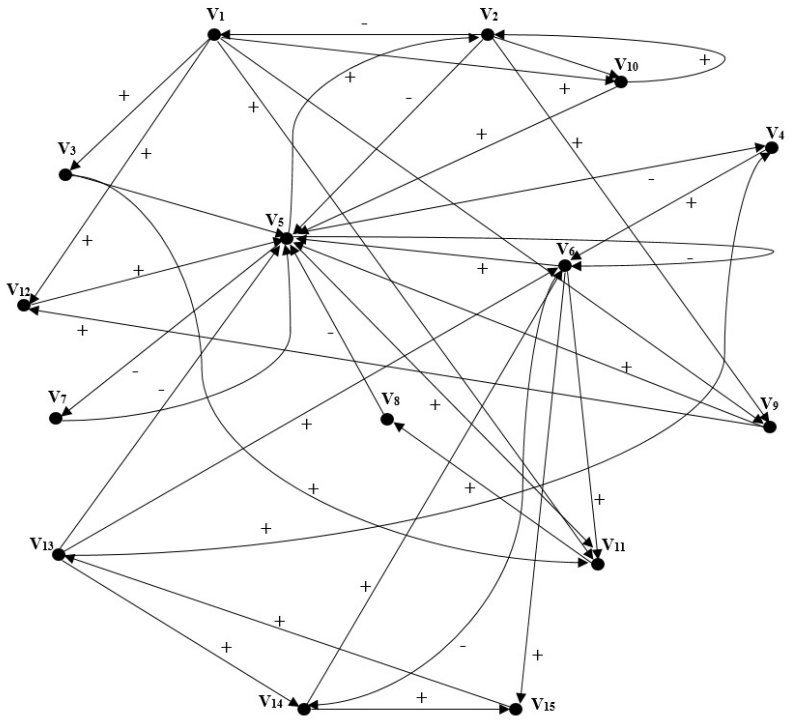


Fig. 2. Generalized Industry Model

$V_3 \overrightarrow{+} V_5$: the increase of the price for the constituent parts of a product cause the rise of the price of the final product and that results in increased inflation;

$V_3 \overrightarrow{+} V_{11}$: to stabilize the market prices, it is likely that the companies will have cartel agreement in case of increasing prices for the constituent parts of a product, to keep the market competitiveness;

$V_4 \overrightarrow{+} V_6$: reduced-rate lending for population leads to growing money supply, that results in increased consumer activity;

$V_5 \overrightarrow{+} V_2$: opposed to long term effect, short term effect of increased inflation leads to the increased Central Bank's key rate and that attracts the foreign investors who are interested in assets, denominated in the local currency, therefore, the demand for local currency also increases favoring its strengthening;

$V_5 \overrightarrow{-} V_4$: increased inflation leads to the necessity to decrease monetary supply to restrict uncontrolled population purchases, that causes closures of reduced-rate lending for population;

$V_5 \overrightarrow{-} V_6$: increased inflation and prices for goods leads to decreasing demand on the local market;

$V_5 \overrightarrow{-} V_7$: increased inflation and prices for commodities leads to decline of growth rate in fiscal stimulating;

$V_5 \overrightarrow{+} V_{11}$: increased inflation leads to the increased prices for the products and that can make the "price-takers" companies establish a certain mechanism to control the prices, which are potentially ahead of inflation rate;

$V_6 \overrightarrow{+} V_5$: direct correlation is obvious, demand inflation.

$V_6 \overrightarrow{+} V_{11}$: probability of price fixing agreement between companies to keep a certain price level on the market increases if the demand rises, i.e. the new consumers and capital come to the market;

$V_6 \overrightarrow{-} V_{14}$: the dramatic demand for the products leads to its deficit, that implies decrease of unusually high consumer activity which is a result of panic;

$V_7 \overrightarrow{+} V_5$: the growth of fiscal stimulation leads to increased monetary supply and, as a result, to inflation growth;

$V_8 \overrightarrow{-} V_5$: active measures of the Federal Antitrust Authority will control price policy of the company which market share is rather large, therefore, that positively affects inflation rise;

$V_9 \overrightarrow{+} V_5$: the higher cost of import equipment in local currency, the higher price of the product (product

costs always impact on the price), therefore, increased price of import equipment exerts pressure on the inflation;

$V_9 \overrightarrow{+} V_{12}$: the rise of monetary terms of import equipment results in increased costs of goods production;

$V_{10} \overrightarrow{+} V_2$: the more goods are exported, the more foreign currency comes to local market, the greater demand on conversion of foreign currency into the local one (to pay taxes and to develop business) appears. All that strengthens the local currency;

$V_{10} \overrightarrow{+} V_5$: the more goods are exported, the higher inflation pressure from export prices on the goods is. The difference between lower prices on domestic market and higher prices on overseas markets is compensated by increasing prices on the domestic market;

$V_{11} \overrightarrow{+} V_8$: the Federal Antitrust Authority starts actively examining the companies if there is a price fixing agreement between the companies-stakeholders;

$V_{12} \overrightarrow{+} V_5$: the rise of production costs increases the price of the goods that resulted in growing inflation;

$V_{13} \overrightarrow{+} V_4$: the lockdowns are accompanied with decreased economic activities, and the measures, such as reduced-rate lending for population and business, are applied to recover economy;

$V_{13} \rightrightarrows V_5$: the lockdowns stop business operations, cause unemployment and decrease of aggregate inflation;

$V_{13} \overrightarrow{+} V_6$: the lockdowns launch dramatic demand on the essential goods as well as expensive material assets. At the same time, there is a fall of demand for services which do not have profound effect on inflation, therefore, we consider this bond as a positive one;

$V_{13} \overrightarrow{+} V_{14}$: the correlation is clear;

$V_{13} \overrightarrow{+} V_{14}$: the population panic results in uncontrolled demand on the essential products;

$V_{14} \overrightarrow{+} V_{15}$: naturally, to prevent the population panic, the government imposes the preventive measures;

$V_{15} \overrightarrow{+} V_{13}$: mitigating measures of the government cancels lockdowns to restore business and to normalize business activities among the population.

Incidence matrix of the graph is given in the Table 1.

Next, we need to find all unbalanced cycles which length is more than 2. There are 5 such cycles in the given system:

1. $V_{10}\, V_2\, V_1$;
2. $V_5\, V_{11}\, V_8$;
3. $V_4\, V_6\, V_5$;
4. $V_{14}\, V_{15}\, V_{13}\, V_6$;
5. $V_{13}\, V_4\, V_6\, V_{14}\, V_{15}$;
6. $V_{13}\, V_5\, V_4\, V_6\, V_{14}\, V_{15}$;

Table 1. Incidence matrix of the graph

	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}
V_1	0	0	1	0	0	0	0	0	1	1	1	1	0	0	0
V_2	-1	0	0	0	-1	0	0	0	1	-1	0	0	0	0	0
V_3	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
V_4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
V_5	0	1	0	-1	0	-1	-1	0	0	0	1	0	0	0	0
V_6	0	0	0	0	1	0	0	0	0	0	1	0	0	-1	0
V_7	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
V_8	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0
V_9	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
V_{10}	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
V_{11}	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
V_{12}	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
V_{13}	0	0	0	4	-1	0	0	0	0	0	0	0	0	1	0
V_{14}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
V_{15}	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Disbalance of these cycles makes the system state unsteady, therefore, it is important to control the model by means of special measures.

As for the first unbalanced cycle, it is evident that there are some measures, such as export quotas, to regulate the export.

The second unbalanced cycle is the result of cartel agreements. Preventive measures conducted by the Federal Antitrust Authority aimed at controlling such problem often can be late. The time lag can cause an uncontrolled oscillations of consumption price index. One of the possible methods to control such agreements is the unified database of product costs which will be accessed by the regulatory bodies. Using this database, one could compare different companies from the same industry, as well as to track large deviations of price policies from the expected price behavior.

The third unbalanced cycle requires operational control of certain economic sectors which could obtain large capital inflow due to stimulation. For example, the growth of favorable mortage loans resulted in uncontrolled growth of the prices on real estate because the demand on the real estate had increased manifold. The demand growth is explained by purchasing real estate as investments, that had never occurred massively in this area before. Thus, stimulation of population to buy real estate led to demand surplus, hence, increased inflation and real estate price. It is important to stiffen requirements for obtaining favorable credit conditions to avoid excessive demand on the market.

The fourth unbalanced cycle reflects only instinctive behavior of the individuals. To normalize fluctuations of the given cycle, the controlling bodies must instantly respond to population panic.

The fifth and the sixth cycles shows the influence of the lockdowns which brought overwhelming cheap financing to the economy. The methods of normalizing such fluctuations in the system are similar to the cycle 3.

4. Conclusion

The designed multifactor model demonstrates that, generally, the system, describing macroeconomic functioning of some industries, is rather steady in the ideal world: presence of controlling bodies and regulators should provide ideal environment for gradual and predictable positioning of inflation expectations.

Since we face unpredictable events, it is getting difficult to predict the inflation dynamics with high accuracy. The new factors which make the state of the system unsteady appear. When the system becomes unstable, any prognostic methods automatically stop working efficiently that causes inadequate estimation of the inflation, all that leads to the increased volatility on financial markets and weaknesses of economic environment.

The obtained system should offset inflation fluctuations caused by the unbalanced graph cycles. Application of additional controlling actions is necessary to maintain not only the generalized inflation within the target range but also each constituent of CPI, because even one industry of economy may have profound effect on the aggregate indicator. Maintenance of one particular inflation of the specific industry within the specific range will favor predictability of the Central Bank's activities, that will positively affect social and economic climate of the state.

Modeling of various systems by means of cognitive graphs helps clearly define weak points of the system and to act against their negative impact by introducing additional factors into the system in order to create new bonds or to destroy the old ones.

In the given system, the unbalances cycles were plotted on the graph and the controlling actions were found in such a way to make the system more resistant to the oscillations. Thus, unpredictable inflation fluctuations in each industry can be prevented by the proposed events. That will allow the government to conduct clear policy concerning macroeconomic conditions and allow citizens and entrepreneurs to trust the inflation dynamics forecast produced by the Central Bank. All that makes it possible to take urgent measures on financing business, issuing credits and depositing to provide healthy business climate in the state.

Information is formalized knowledge. Knowledge must be formalized, written down in some generally understandable way and transferred where necessary. And the receiving party must decipher this information and, like a nucleolus from a nut shell, peel knowledge out of this information. But here, too, there is an objection. Information about knowledge does not need to be written down in a commonly understood way. Information about it should be clear only to the receiving party. Let us

pay attention to one more nuance in the difference between knowledge and information: “Knowledge” is produced, born, extracted: “Information” involves the transfer of it (information), while what is transferred already exists and is either again information or knowledge.

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Графовая аналитика для задач цифровой экономики

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Аннотация: В статье рассматриваются теоретические и практические примеры использования графовой аналитики для решения приоритетных задач цифровой экономики, как первой ступени экономики знаний. Во-первых, авторы обрисовывают имитационную модель, которую можно использовать для отслеживания колебаний инфляции. Поскольку рост инфляции может отражать рост цен на товары и услуги, а также то, как потребители теряют свои позиции по мере того, как на свои доходы они покупают меньше товаров, прогнозирование инфляции и ее последствий может иметь большое значение. Представленная модель основана на когнитивном графе. Когни-

тивный граф имеет 15 вершин, которые являются факторами, влияющими на экономику. Анализируются связи между вершинами и формируется матрица инцидентности. Далее в графе распознаются несбалансированные циклы, длина которых больше 2. Именно эти несбалансированные циклы обычно вызывают инфляцию и наносят ущерб экономике. Эта модель позволяет рассмотреть 5 несбалансированных циклов, а ее использование позволяет правительству (лицам, принимающим решения) контролировать и ограничивать влияние инфляции на экономику. Также представлены теоретические основы применения когнитивных графов для количественной оценки знаний.

Ключевые слова: цифровая экономика, экономика знаний, инфляция; имитационное моделирование; когнитивный граф; графовая аналитика; индекс потребительских цен; ключевая ставка.

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