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RESEARCH ON INVESTMENT PROCESS DYNAMICS TAKING INTO CONSIDERATION STOCHASTICITY OF WORLD AND NATIONAL ECONOMIES' CRISIS PHENOMENA

Purpose. To analyze the flows of foreign direct investment (FDI) in Ukraine, countries of the OECD, the G-20, the EU, and the World, as well as the impact of the coronavirus COVID-19 pandemic on investment activity in the World; to identify problems and threats for investment activity in modern conditions, to identify relationship between FDI in Ukraine, the level of exports and imports of goods and services in Ukraine, to forecast these indicators.

Methodology. In the process of research, general logical methods and research techniques were applied: analysis, synthesis, generalization, analogy, modeling, probabilistic (statistical) methods. The materials of the official analytical reports of the OECD, the European Commission, and the State Statistics Service of Ukraine were used to achieve the tasks of the investigation. The statistical data for the period 2011–2019 was analyzed. Forecast of foreign direct investment in Ukraine for the period 2020–2023 was implemented using the theory of Markov chains.

Findings. The study indicates a significant decline in investment activity since the beginning of 2020 due to the coronavirus COVID-19 pandemic. Almost all economies in the world witnessed the impact of the crisis. There was a drop in investment activity in Ukraine – output flows tended to decrease during 2009–2019. Taking into account the stochasticity of the processes taking place in the world economy, on the basis of the theory of Markov chains, forecasting of FDI in Ukraine was carried out. The modeling showed that in 2023 the situation with FDI in Ukraine would stabilize. Taking into account the predicted scenarios, the authors suggested that enterprises must focus on domestic investment and government support to overcome the crisis in the economy caused by the situation with COVID-19.

Originality. The scientific novelty is in the use of the theory of Markov chains, which was adapted by the authors for research and forecasting of FDI in Ukraine till 2023. This theory makes it possible to take into account the stochasticity and instability of the processes occurring in the global and national economies.

Practical value. The analysis of incoming and outcoming FDI flows and the identified threats to investment activity makes it possible to assess the dynamics of world economic processes and global competitiveness in the period 2011–2020. Using the tools of economic and mathematical analysis based on the regression influence, the degree of influence of direct investments in Ukraine on the dynamics of the GDP of the national economy and the level of exports and imports of goods were investigated. The forecasting of the dynamics of direct investments in Ukraine in the near future was carried out using the theory of Markov chains, which will allow working out appropriate decisions on the strategic development of the state.

Keywords: *foreign direct investment, modeling, forecasting, Markov chains, export, import*

Introduction. As a result of global trends, the economies of the world and Ukraine in particular, found themselves in a fundamentally new state facing new challenges. Energy dependence, political instability, global socio-cultural shifts, the spread of risk carriers or vectors such as epidemics in recent years have led to the need of study and analysis of progressive and reversible trends in economic processes and new ways, mechanisms and searching methods to manage them.

Intensive technological progress and digitalization lead to the obsolescence of the production base, deterioration of industrial equipment, lack of qualified personnel, investments, and therefore to a change in approaches to strategic development of the enterprise, a structural part of economy.

It is impossible to move to innovative way of economic development without overcoming the stage of the investment path, because qualitatively new tangible and intangible resources are required for creation of a new technical and technological basis for the industrial complex, which Ukraine, in particular, is currently unable to provide for national production fully. Of course, most investment costs are at least partially irreversible, that is they cannot be recovered under unstable market conditions. As a result, the cost of the investment includes the cost of the potential risk. The literature available shows how this opportunity cost can be estimated and proves that it is very sensitive to uncertainty. That is why changes in market conditions that affect the risk of future cash flows can have a major impact on investment costs. This situation emphasizes the role of uncertainty as a determinant of investment costs and suggests that policies aimed at reducing economic volatility (e.g., regulation to reduce exchange rates, prices, interest rates) can reduce the necessary investment costs.

Literature review. Most of the analyzed scientific publications on investing in various spheres of economy are undoubtedly informative and relevant in terms of assessing investment indicators and their impact on various spheres of state functioning.

In particular, Samotoenkova O. [1] discusses the investment processes in the economy of Ukraine. She provides a detailed analysis of the dynamics of FDI in Ukraine, their structure by type of economic activity and sources of funding. However, in our opinion, insufficient attention is paid to the problem of investing in high-tech sectors of the economy, the situation with outgoing FDI is not reflected, and proposals to monitor the situation and create incentives for investment are quite declarative.

In the article by A. Kolevatov [2] a study on the state and level of foreign investment in the economy of Ukraine was made. It was determined that investment attractiveness is influenced by the general state of the economy, business conditions, including the degree of state intervention and corruption. Among the possible ways to improve the investment climate in Ukraine, the author highlights, in particular, the introduction of mechanisms for individual investors in financial market operations, development of long-term lending programs for individual investments, including energy efficiency, education, housebuilding, which is certainly relevant and important.

The study by Danyliuk V., et al. "Functional and investment strategies of technical development of enterprises" is relevant in the context of investing an individual enterprise as an economic unit. The article analyzes general problems of imbalance between the overall strategy of enterprise development and its investment, production and functional strategies, which leads to a decrease in management and business efficiency. The study critically evaluates different views on the concept of technical development strategy and its interrelationship with investment [3].

It should be noted that investment behavior in crisis situations changes from year to year in accordance with the dynamics of globalization processes. Since investors today are more concerned about the depth and duration of the crisis caused by the coronavirus COVID-19 pandemic, research and suggestions for making decisions on investing in the crisis are especially important. Economic systems have been hit by unprecedented negative impacts since the beginning of 2020 and have been experiencing disruption of global production networks on a scale never seen before. The disruption of FDI flows, which are integral part of economic globalization, is no exception.

In this context, the work by Jaworek, M., Karaszewski, W., & Kuczmarska, M. [4] is of scientific interest. The authors showed that investors do not take into account certain threats in their risk assessments, such as natural disasters, epidemics or pandemics. They argue that conducting FDI organizations focused mainly on risk assessment of the country in which they wanted to invest. This article states that, according to a 2017 UNCTAD study, multinational companies identify global sources of risk mainly as geopolitical uncertainty, terrorism, and social instability, rather than natural disasters (including pandemics). Although respondents of the study almost completely ignored the risk of a pandemic, UNCTAD predicts a 30–40 % reduction in FDI in 2020–2021.

This paper is of considerable scientific interest because it analyzes and assesses trends in FDI that are affected by current challenges and threats. However, in our opinion, since such natural disasters and threats as pandemics are a factor that cannot be predicted and taken into account in investment activities, it is worth proposing situational response and step-by-step solutions during the crisis, especially a protracted one.

However, in general, in the works by national and foreign scientists almost no attention was paid to the method of forecasting economic and social research processes using methods based on the theory of Markov chains with discrete states.

Unsolved aspects of the problem. Thus, increasing the competitiveness of domestic products and entering domestic and foreign markets for import substitution is associated with the threat of appearance of new competitors, substitute products, the rivalry of existing competitors for Ukrainian producers.

The situation, on the one hand, is complicated by the fact that investment problems of leading industries have to be solved during economic crisis, when "freezing" of funds for the implementation of projects of domestic sectors development negatively affects the efficiency of the entire economic system. On the other hand, the need for investment to restructure and reform the entire economy is constantly growing as a result of the necessity to upgrade existing production facilities. With a view to the destruction of foreign economic relations with near- and far abroad countries, the activities of a number of chemical enterprises, machine-building enterprises, light industry, construction industry, etc. were suspended in Ukraine. Today, it can be already felt that all the existing negative trends that have developed recently due to COVID-19 cannot be overcome without balanced and wise political decisions and steps that would act in the national interest. All this gives grounds to claim that it is expedient to conduct a study to determine the correlation of FDI in Ukraine to the level of exports and imports of goods and GDP of Ukraine, as well as forecasting FDI to Ukraine for 2020–2023 based on the Markov chain theory – a sequence of random events with a finite number of possible endings, where the future depends on the current state, but does not depend on the past.

Purpose. The purpose of the article is to analyze the flows of foreign direct investment of Ukraine, countries of the OECD, G-20, EU, World, as well as the impact of the coronavirus COVID-19 pandemic on investment activity in the world; to identify problems and threats for investment activities in modern conditions. Also, the aim of the study is to identify the relationship between FDI in Ukraine, the level of exports and imports of goods and services in Ukraine and to forecast these indicators using the theory of Markov chains.

Methods. The materials of official analytical reports of the OECD, the European Commission, and the State Statistics Service of Ukraine were used during the research. The statistical data for the period 2011–2019 were analyzed. On the basis of correlation-regression analysis the correlation between the factors "direct investments in Ukraine" and "Imports of goods to Ukraine" were studied, the influence of the level of direct investment in Ukraine on GDP was investigated, the correlation of direct investment influence in Ukraine at the level of exports of goods from Ukraine was analyzed. A method based on the Markov chain theory was used to forecast the dynamics of direct investment in Ukraine. It takes into account the stochastic processes of economic systems.

Results. FDI flows reflect the value of cross-border direct investment transactions over a certain period of time [5]. It is worth noting that there are FDI inflows and FDI outflows. FDI inflows are the amount of direct investment made by non-resident investors in a country's economy. FDI outflows are transactions made by residents of a country to the economies of other countries. These are external direct investments, which are also called foreign direct investments [6].

In general, FDI outflows showed a significant decline in 2014 and 2018 for all indicators listed in Table 1.

Global foreign direct investment flows fell by 20 % in the first half of 2019 to $572 billion. They fell by 5 % in the first quarter of 2019 and by 42 % in the second quarter. FDI inflows to the OECD countries decreased by 43 % in 2019, mainly due to reduced flows to the Netherlands, the United States and the United Kingdom and disinvestment from Belgium and Ireland. Foreign direct investment from the OECD region increased by 2 % in 2019 [8].

The dynamics of investment in the World, OECD, EU, G-20 countries are shown in Table 2.

The lowest value of FDI inflows to the World, OECD, EU, G-20 was observed in 2018. The lowest investments in EU countries were in 2014 and 2017 – $ 253451 million and $ 290202 million, respectively.

Table 1

FDI outflows, million USD [7, 8]

Year / Indicator	2011	2012	2013	2014	2015	2016	2017	2018
World	1 538 981	1 256 364	1 348 459	1 296 827	1 650 743	1 527 869	1 402 637	890 154
OECD	1 217 567	819 953	985 605	806 665	1 241 583	1 121 447	1 073 214	577 218
EU	481 804	299 534	344 563	214 226	607 469	464 983	425 423	349 754
Countries of the G-20	1 033 836	819 078	855 084	775 095	815 265	909 246	1 050 176	612 588
Countries of the G-20, which are OECD members	900 709	708 676	691 712	551 779	585 231	665 395	886 474	435 150
Countries of the G-20, which are not participants of OECD	133 127	110 401	163 372	223 315	230 033	243 851	163 701	177 438

Table 2

FDI inflows, million USD [7, 8]

Year / Indicator	2011	2012	2013	2014	2015	2016	2017	2018
World	1 728 106	1 535 270	1 588 928	1 501 920	2 057 817	1 009 828	1 419 482	1 420 309
OECD	895 354	728 352	788 863	669 070	1 206 968	1 200 472	759 827	726 129
EU	424 946	336 348	347 418	253 451	519 177	531 044	290 202	357 665
Countries of the G-20	1 065 661	883 346	1 008 100	856 217	1 117 568	1 208 037	876 820	951 143
Countries of the G-20, which are OECD members	565 897	460 804	536 258	410 366	716 650	881 044	539 753	590 920
Countries of the G-20, which are not OECD members	499 764	422 542	471 842	445 851	400 917	326 994	337 068	360 222

FDI inflows for the first and second quarters of 2019 amounted: to OECD countries – $ 303740 million, the World –$ 618070 million, EU – $ 107066 million, G-20 – $ 483979 million; G-20 countries that are members of the OECD – $310187 million, G-20 countries that are not members of the OECD – $ 173793 million [8].

While FDI flows to OECD countries which are participants of the G20 decreased by 19 %, FDI flows to non-OECD countries increased by 21 % in the first half of 2019. The increase in flows was due to increase investments in Russia, China and India. In the first half of 2019, the main recipients of FDI worldwide were the United States, China, France, Brazil and India [9].

In light of the events of early 2020, it is impossible not to mention the impact of the coronavirus COVID-19 pandemic on investment activity in the world. At the end of March 2020, the International Monetary Fund announced that investors had withdrawn $ 83 billion from emerging markets. Since the onset of the COVID-19 crisis, this is the largest capital outflow ever recorded [10]. FDI is expected to decline sharply due to the pandemic and the effects of supply disruptions, reduced demand and pessimistic forecasts of economic agents.

The latest data from FDI Markets Financial Times database provides additional evidence that investors are reluctant to consider new investment opportunities amid the pandemic. The fall in investment is more evident in non-OECD countries, where the value of green FDI fell by more than 36 % compared to 2019 and by 15–30 % compared to 2018 [11].

Despite the G20's commitments to contain FDI and trade continued during COVID-19, some countries impose restrictions on inflow investments [12].

Due to the uncertainty of economic and political events and still high level of indebtedness in parts of the EU economy, the access of small and medium-sized enterprises to finance (in particular loans) was difficult [13]. It is also worth noting that the EU suffers from low investment levels and high unemployment rates since the beginning of the world economic and financial crisis of 2008–2009.

Analysis of statistical reports and other scientific data has led to the conclusion that the European Union is at risk of gradually losing global competitiveness, in consequence of slow introduction of innovation, digital technologies and increased productivity that resists rapid technological change around the world and the emergence of new global competitors. In particular, there are the following threats to boost investment in the EU [14]:

- research and development (R&D) expenditure in the European Union lags behind that in peer economies, and is over-dependent on the automotive sector. It should be noted that growth in European production slowed sharply in 2018 and early 2019;
- the adoption of digital technologies in Europe is slow, with a growing digital divide among firms. The share of digital firms in the European Union's manufacturing sector, 66 %, is lower than in the United States, 78 %, with an even larger gap of 40 to 61 % in services;
- Europe has too few start-ups and scale-ups, with the United States having four times as many per inhabitant compared to the European Union.

As for Ukraine, it can be stated that FDI is available in all sectors of the Ukrainian economy today. At the same time, most investors on the Ukrainian market are willing to invest in the processing industry, as well as wholesale and retail trade – where new products appear quickly, the range changes, costs and low commercial risks pay back quickly. Also those industries are popular that do not require long-term investment and development of new technologies, including the financial and real estate sectors [15].

The largest investments were made in the economy of Ukraine in the period 2009–2013, followed by the largest decline in 2013–2014, 2017, which was obviously due to the unstable socio-political situation, the conflict in the east of the country [16].

FDI inflows and outflows are given in Table 3.

Table 3

Foreign direct investment in Ukraine during 2009–2019, million USD [16]

Year	Foreign direct investment in Ukraine, million dollars USA			
	FDI inflows	Balance (compared to the previous year)	FDI outflows	Balance (compared to the previous year)
2009	4816		162	
2010	6495	+1679	736	+574
2011	7207	+712	192	–544
2012	8401	+1194	1206	+1014
2013	4499	–3902	420	–786
2014	410	–4089	111	–309
2015	2961	+2551	–51	–162
2016	3284	+323	16	+67
2017	2202	–1082	8	–8
2018	2355	+153	–5	–13
2019	1711	–644	0	+5

In 2018, the following countries invested the most in the Ukrainian economy: Cyprus – $ 8919.7 million, the Netherlands – $ 6452.7 million, Great Britain – $ 2047.9 million, Germany – $ 1824.7 million, Switzerland – $ 1532.9 million, the Virgin Islands (Britain) – $ 1320.7 million, Austria – $ 1018.8 million, Russia – $ 797.1 million, France – $ 753.6 million, Poland – $ 612.8 million, Hungary – $ 544.8 million, and so on [15].

The inflow of foreign investment into the national economy on the basis of synergetic impact dynamically affects the increase in the productive potential of the national economy and household incomes. Mathematical modeling of the impact of foreign direct investment on the macroeconomic indicators of the Ukrainian economy was investigated and performed.

The Table 4 presents the dynamics of the main macroeconomic indicators of Ukraine's economy.

As can be seen from Table 4 for the period 2015–2019, the balance of general indicators of foreign trade in goods was positive only in 2015 and amounted to $ 610.7 million. But it was negative – $ 2888.1 million in 2016, $ 9852.6 million in 2018, and $ 10745.6 million in 2019. This is despite the fact that the GDP of the national economy for the analyzed period grew dynamically. This situation is a consequence of an increase in imports and a decrease in exports of goods, which is a negative trend and indicates a decline in the production of goods and, in the end, can lead to negative consequences in the dynamics of macroeconomic indicators of the national economy. The data in Table 3 indicate that FDI in Ukraine in the period 2016–2018 fluctuated with a downward trend – from $ 3284 million in 2016 down to $ 1711 million in 2019. At the same time, the general indicators of foreign trade in services for the period 2016–2018 have a positive trend and a positive balance. The balance of exports to imports of foreign trade in services in 2016 amounted to $ 4541.5 million, $ 5329.1 million in 2018, and $ 8686.7 million in 2019, which indicates positive dynamics of the indicator.

The main partner countries of Ukraine in the export of goods in 2018–2019 were: Russia – 7.7 %, Poland – 6.9 %, Italy – 5.6 %, Turkey – 5.0 %, Germany – 4.7 %, China – 4.6 %, India – 4.6 %, Hungary – 3.5 % of total exports. The main partner countries in the import of goods in 2018 were: Russia – 14.1 %, China 13.3 %, Germany – 10.5 %, Belarus – 6.6 %, Poland – 6.4 %, USA – 5.2 %, Italy – 3.6 % of total import.

The relationship between FDI to Ukraine (Table 3) and the level of export and import of goods in Ukraine (Table 4) were investigated on the basis of correlation-regression influence.

The equation of correlation-regression influence of the import of goods in Ukraine and direct investment in Ukraine took the form

$$y = 1\ 119\ 204 - 343.3x.$$

The coefficient of determination $R^2 = 0.71$, which indicates the adequacy of the constructed model, and the correlation coefficient is 0.51, which indicates a sufficient and direct correlation of direct investment on the import of goods to Ukraine.

A study on the impact of FDI on Ukraine's GDP was conducted. The regression equation of this model took the form

$$y = 71\ 388.52 - 12.2x.$$

The coefficient of determination $R^2 = 0.85$, which indicates the adequacy of the constructed model, the correlation index is 0.72, which indicates a strong correlation and impact of direct investment in Ukraine on the GDP of the national economy. It means that if the dynamics of direct investment to Ukraine grows, the dynamics of GDP will grow as well.

The influence of FDI in Ukraine on the level of goods exports from Ukraine was studied. The equation of correlation-regression influence of indicators took the form

$$y = 65\ 755.44 - 9.1x.$$

The coefficient of determination of this model $R^2 = 0.93$, which indicates the adequacy of the constructed model, and the correlation coefficient is 0.88, which indicates a close and

Table 4

Dynamics of macroeconomic indicators of the national economy for the period 2016–2019 [17]

Indicator	2015	2016	2017	2018	2019
GDP, UAH billion	1988.5	2385.4	2983.9	3558.7	3974.8
External trade performance in goods					
Exports, US dollars, million	38 127.1	36 361.7	43 264.7	47 335.0	50 054.6
Imports, US dollars, million	37 516.4	39 249.8	49 607.2	571 876	608 002
Balance	610.7	–2888.1	–6342.5	–9852.6	–10 745.6
External trade performance in services					
Exports, US dollars, million	9736.6	9868.0	10 714.3	11 637.9	15 628.9
Imports, US dollars, million	5523.0	5326.5	5476.1	6308.8	6942.2
Balance	4213.6	4541.5	5238.2	5329.1	8686.7

direct correlation between the selected factors. That is, to increase the level of export of goods from Ukraine, it is necessary, as one of the factors, to increase direct investment in Ukraine.

Since the processes in both national and global economy do not always follow linear laws of development, but there is uncertainty and stochasticity, therefore, a forecast of FDI in Ukraine was carried out using the theory of Markov chains. The processes that have been taking place in the world economy, including COVID-19 epidemic influence, were considered. The theory allows take into account the current state of the system, considering the retrospective, for the possibility of forecasting the state of the economic system in the near future.

It should be noted that most economic and social processes develop as random processes under the influence of random factors. It is necessary to build a probabilistic model to predict the future state of these processes.

A random process occurring in the system S is called a Markov process – for each moment of time t_0 the probability of any state of the system in the future (at $t > t_0$) depends only on its state in the present time (at $t = t_0$) and does not depend on when and how the system came to this state. In other words, in the Markov random process, the future state of the system depends on the present time and does not depend on the "prehistory" of the process [18]. The greatest interest for economic forecasting is the Markov random process (Markov chains) with discrete states. We will assume that for each state of the system the probabilities of transition to another state in one step are known. We will note by p_{ij} the probability of transition of the system S from the state i and to the state j for the period of time from t_0 to t. Let the system S have n possible states S_1, S_2, ... S_n. The transition of probabilities p_{ij} is presented in the form of a transition matrix $\|p_{ij}\|$

$$p_{ij} = \begin{matrix} p_{11} & p_{12} & p_{1j} \\ p_{21} & p_{22} & p_{2j} \\ p_{n1} & p_{n2} & p_{nj} \end{matrix}. \quad (1)$$

The sum of all elements of each row of the matrix is equal to 1, because for the time interval t the Markov chain from state i will necessarily pass into one of the admissible states j, that is

$$\sum_{j=1}^{n} p_{ij} = 1. \quad (2)$$

The square matrix $\|p_{ij}\|$ is called stochastic because all its elements are non-negative and the sum of all elements of each row of the matrix is equal to one. In order to completely define Markov chain, it is necessary to have a vector of the initial state of the system p_i in addition to the matrix of transient probabilities. The vector string p_i is called the probability vector. Obviously, all elements of the vector are non-negative, and the sum of the elements is equal to one, that is

$$\sum_{j=1}^{n} p_{ij}(t_0) = 1. \quad (3)$$

The initial state of the system can be specified using a probabilistic row vector, one of the elements of which is equal to 1, and all other elements are equal to 0.

It is proved that the vector of probabilities of Markov chain at time t is equal to the product of the vector of probabilities at the initial time t_0 and the transition matrix [18], that is

$$p(t) = p(t_0) \cdot p_{ij}. \quad (4)$$

Analyzing the dynamics of FDI in Ukraine (Table 3), we will assume that the system was in the following states: increased growth (2016) – 0; insignificant dynamics of the indicator's decline (2017) – 0; slight recovery of the indicator growth (2018) – 0 dynamic indicator's decline (2019) – 1.

Then the vector of the dynamics of direct investment revival in Ukraine will be P = [0 0 0 1].

The input data of the FDI indicator in Ukraine for the period 2016–2019 (Table 3), and a listing of calculations made in the Matlab program presented below (Figure)

```
>> A = [1711;2355;2020;3284]
A =
        1711
        2355
        2020
        3284
>> C = [9370;9370;9370;9370]
C =
        9370
        9370
        9370
        9370
>> rdinide(A,C)
ans =
        0.1826
        0.2513
        0.2156
        0.3505
> B = [0.1826 0.2513 0.2156 0.3505;0.2513 0.2156 0.3505
  0.1826; 0.2156 0.3505 0.1826 0.2513; 0.3505 0.1826 0.2513
  0.2156]
```

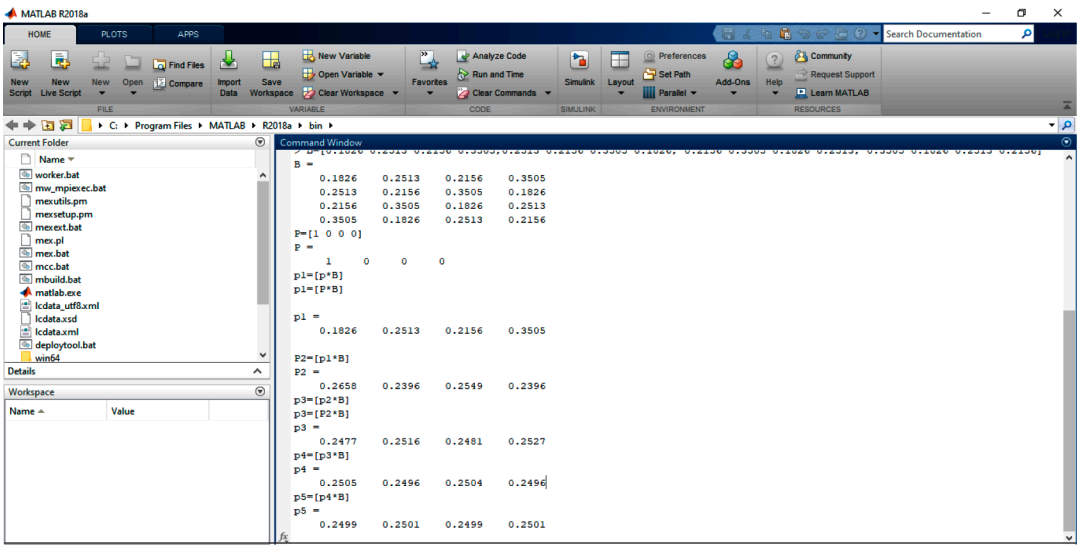

Fig. The result of forecasting FDI in Ukraine based on the Markov chain theory in the Matlab software environment

```
B =
    0.1826    0.2513    0.2156    0.3505
    0.2513    0.2156    0.3505    0.1826
    0.2156    0.3505    0.1826    0.2513
    0.3505    0.1826    0.2513    0.2156
>> P = [1 0 0 0]
P =
     1   0   0   0
>> p1 = [p*B]
>> p1 = [P*B]
p1 =
    0.1826   0.2513   0.2156   0.3505
>> P2 = [p1*B]
P2 =
    0.2658   0.2396   0.2549  0.2396
>> p3 = [p2*B]
>> p3 = [P2*B]
p3 =
    0.2477   0.2516   0.2481   0.2527
>> p4 = [p3*B]
p4 =
    0.2505   0.2496   0.2504   0.2496
>> p5 = [p4*B]
p5 =
    0.2499   0.2501   0.2499   0.2501.
```

Therefore, according to the forecast using the principles of the Markov chain theory at step p_1, in 2020, the system will be in a state of dynamic decline with the highest probability (coefficient 0.3505). In the second step p_2 the system will be in a state of slight dynamic decline with the highest probability (coefficient 0.2658), and only in the fifth step p_5, in 2023, the situation with FDI in Ukraine will stabilize with a fairly high probability of 0.2499. However, there is a probability of a decrease in the dynamics of the indicator during this period (probability coefficient 0.2501). Therefore, in our opinion, the national economy should focus more on domestic investment, government support for businesses and companies to overcome the crisis in the economy.

Conclusions. FDI, being continually and significantly affected by negative developments in the world, such as natural disasters, epidemics or pandemics, is a vital resource for any economy. These threats, at present, form the main vector of prospects and trends perception in the field of international investment. Developing countries suffer the most from underinvestment, as export-oriented and commodity-related investments have been among the most serious problems since 2020.

Global FDI flows for the period 2011–2019 tend to decrease. The lowest value of FDI inflows to countries of the World, OECD, EU, G-20 was observed in 2018. The least investments in EU countries were in 2014. While the flow of FDI to OECD countries belonging to the G20 decreased, flows of FDI to non-OECD countries increased in the first half of 2019. Most investments in Ukraine's economy were made in 2009–2013, followed by the largest decline in 2013–2014, 2017, which was apparently associated with the unstable socio-political situation, the conflict in the east of the country.

The study shows a significant decline in investment activity since the beginning of 2020 due to the coronavirus COVID-19 pandemic. It is worth noting that almost all economies of the world, Ukraine in particular, have suffered. Thus, in the period 2009–2019 there was a decline in investment activity in Ukraine – output flows tend to decrease. Some countries have imposed restrictions on inward investment, despite the G20's commitment to retain FDI during COVID-19, and have focused on investing in those areas that are crucial to suppression of the virus spread.

In this study, using the tools of economic and mathematical modeling, we found that the correlation coefficient of FDI in Ukraine and GDP of the national economy is 0.72, that is it is necessary to attract direct investment in Ukraine to create a positive dynamics of GDP; the correlation coefficient of FDI to Ukraine and the level of exports is 0.88, that is to increase exports of goods from Ukraine we need to increase FDI to Ukraine as one of the factors. The forecast of FDI to Ukraine was made based on the Markov chain theory. The stochastic nature of the processes in the world economy was taken into account during the forecast. The simulation showed that only on the fifth step p_5, in 2023, the situation with FDI in Ukraine will somewhat stabilize, with a fairly high probability of 0.2499 the system will be in a state of increasing growth, and with the same probability coefficient of 0.2499, there will be a slight revival of growth in direct investment in Ukraine, although a decrease in the dynamics of the indicator is also possible with a probability factor of 0.2501. FDI in Ukraine will arrive approximately in the amount of $2020 million. Therefore, in our opinion, the national economy should focus more on domestic investment and government support for businesses and companies to overcome the crisis in the economy caused by the situation with COVID-19.

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Дослідження динаміки інвестиційних процесів з урахуванням стохастичності кризових явищ у світовій і національній економіці

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Мета. Полягає в аналізі потоків прямих іноземних інвестицій (ПІІ) України, країн ОЕСР, G-20, ЄС, світу, а також впливу пандемії коронавірусу COVID-19 на інвестиційну активність у світі; виявленні проблеми й загрози для інвестиційної діяльності в сучасних умовах, у виявленні залежності між (ПІІ) в Україну, рівнем експорту та імпорту товарів і послуг в Україні, здійсненні прогнозування даних показників.

Методика. У процесі дослідження застосовані загальнологічні методи та прийоми дослідження: аналіз, синтез, узагальнення, аналогія, моделювання, вірогіднісні (статистичні) методи. Для досягнення поставлених завдань використані матеріали офіційних аналітичних доповідей ОЕСР, Європейської Комісії, Державної Служби Статистики України. Проаналізовані статистичні дані за період 2011–2019 рр. Прогноз прямих іноземних інвестицій в Україну на період 2020–2023 рр. здійснено з використанням теорії ланцюгів Маркова.

Результати. Дослідження свідчить про суттєвий спад інвестиційної активності з початку 2020 р. унаслідок пандемії коронавірусу COVID-19. Постраждали практично всі економіки світу. У період 2009–2019 рр. відбулося падіння інвестиційної активності України – вихідні потоки мали тенденцію до зменшення. Ураховуючи стохастичність процесів, що відбувалися у світовій економіці, на основі теорії ланцюгів Маркова здійснено прогнозування ПІІ в Україну. Моделювання показало, що у 2023 році ситуація з ПІІ в Україну дещо стабілізується. Ураховуючи спрогнозовані сценарії, авторами запропоновано підприємствам орієнтуватися на внутрішні інвестиції та державну підтримку для подолання кризових явищ в економіці, викликаних ситуацією з COVID-19.

Наукова новизна. Полягає у використанні теорії ланцюгів Маркова, що була адаптована авторами для дослідження та прогнозування прямих іноземних інвестицій в Україну до 2023 року. Дана теорія дозволяє враховувати стохастичність та непередбачуваність процесів, що відбуваються у світовій і національній економіці.

Практична значимість. Здійснений аналіз вихідних і вхідних потоків прямих іноземних інвестицій та виявлених загроз для інвестиційної діяльності дає змогу оцінити динаміку світових економічних процесів і глобальної конкурентоспроможності в період 2011–2020 рр. Інструментарієм економіко-математичного аналізу на основі регресійного впливу досліджено міру впливу прямих інвестицій в Україну на динаміку ВВП національної економіки й рівень експорту та імпорту товарів. Здійснене прогнозування динаміки прямих інвестицій в Україну на найближчу перспективу на основі теорії ланцюгів Маркова дасть змогу виробити відповідні рішення щодо стратегічного розвитку держави.

Ключові слова: *прямі іноземні інвестиції, моделювання, прогнозування, ланцюги Маркова, експорт, імпорт*

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