# FINANCING INNOVATION ACTIVITY IN UKRAINE: REALITIES AND PERSPECTIVES

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## ABSTRACT

*The role of the European Union (EU) in direct investment into the real sector of the Ukrainian economy is discussed in the article. Activity indicators of Ukrainian industrial enterprises are analyzed. Assessment of the attraction of foreign direct investment from the EU to the real sector of the Ukrainian economy is provided. The correlation between the influence of the total amount of expenditures for financing innovation activity of industrial enterprises and gross domestic product of Ukraine in actual prices is calculated and forecasting of these expenditures by applying the theory of Markov chains is carried out. The research on the basis of correlation-regression analysis between the total amount of expenditures for financing innovation activity of industrial enterprises and gross domestic product of Ukraine in actual prices for the period of 2013-2017 made it possible to establish a sufficiently strong correlation between the indicators (the correlation coefficient is 1), which indicates that the positive dynamics of the increase in the total amount of expenditures for financing innovation activity of industrial enterprises will lead to a positive dynamics of Ukraine's gross domestic product in actual prices. This, in turn, will improve practically all indicators of the industrial activity of the national economy.*


**Keywords**: investment, innovation activity, Ukraine, gross domestic product, foreign direct investment, Markov chain.

**JEL Classification**: C53, F21, O11, O31.

## 1. INTRODUCTION

The development of Ukraine's industry is closely related to the problem of Ukrainian product competitiveness in the world market, as well as to reconstruction and technical re-equipment of main sectors of Ukraine's economy. Thus, it is important to discuss the situation with capital investments and implementation of strategically important investment projects of innovative nature.

At present, activities of Ukrainian industrial enterprises are mainly focused on introduction of borrowed technologies. There are many reasons for this situation: insufficient financing of fundamental and applied science, lack of necessary funds for scientific and technological development, and unstable economic situation. In addition, the situation is complicated by the fact that at present time only few large, effectively functioning enterprises, organizations and educational institutions have highly skilled professionals employed not only in areas of their narrow professional activity, but also in modern financial system, theory of management, innovation.

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A crisis in a number of industries and a decline in the competitive level of developpments are a result of rapid inflation and rising gas tariffs (by 50.5%) and electricity (by 19.0%) for industrial needs for the period of 2017-2018 (National Energy and Utilities Regulatory Commission of Ukraine 2018; National Joint-Stock Company (NJSC) "Naftogaz" of Ukraine 2018). Such a state of affairs significantly affects the level of competitiveness of Ukrainian products, and again is a risk factor for investing.

Serious concerns about further development of domestic industry have been risen (Ilyash & Dzhadan, & Ostasz 2018), since competitiveness of products and enterprises in general depends on the technical level of equipment and its compliance with the pace of scientific and technological progress. The authors state in the paper that during the last five years there has been a decline in the activities of the Ukrainian innovation policy. The problem of financing innovation activities remains unresolved due to the limited budget funds. It is demonstrated not only by a decrease in the number of industrial enterprises engaged in innovation activities, but also by a decrease of the share of innovation products in general production.

Solving the problem of increasing the level of investment project implementation by Ukrainian enterprises requires a solution of complex technical and organizational issues. At the same time, this problem has an important methodological aspect, which includes the selection of the research method and the system of scientific principles on the basis of which the research is made and the selection of means and methods for forecasting national economy development. These will help assessing the effectiveness of innovation policy conduction. The essence of the problem is that the increase of the level of innovativeness of industrial goods is considerably complicated due to the lack of specific, relatively simple and convenient-for-practical-use methods for estimation and forecast of production activity of economic units-residents in the sphere of tangible and intangible production. Therefore, this issue is required to be solved.

The aim of the paper is to analyze main indicators of Ukraine's industrial enterprises and attraction of foreign direct investments (FDI) from the European Union (EU) into the real sector of Ukrainian economy and to forecast the amount of expenditures for financing innovation activity of industrial enterprises for the period of 2018-2025.

The dynamics of activity of Ukraine's industrial enterprises and its position in the world ratings concerning innovation activity are analyzed in the article.In order to develop a strategy for economic cooperation with the EU countries in attracting investments into innovation activity of industrial enterprises, the experience of Poland and Romania in adapting to the international standards of the EU is further researched. The paper continues with carrying out the economic forecasting of indicators of investment and innovation activity of Ukrainian industrial enterprises using the theory of Markov chains. The last part of the paper belongs to conclusion.

## 2. PREVIOUS RELATED RESEARCH

Schumpeter (1939), the founder of the theory of innovation, considered innovation as the economic impact of technological change, as the use of new combinations of existing productive forces to solve the problems of business. Innovations are, on the one hand, in contradiction with conservatism, aimed at preserving the existing situation; on the other hand, they aim, within the framework of the strategy of changes, to significantly increase the technical and economic efficiency of the organization.

The concept of innovation has evolved considerably over the last 30 years. To define innovation, characterize it and monitor its evolution, the Organization for Economic Co-

operation and Development (OECD) published four editions of the Oslo Manualin 1992, 1997, 2005 and 2018. The first two editions (Manuel d'Oslo 1992; Oslo Manual 1997) focused mainly on the product and process of technological innovation. In 1997, however, the concept of non-technological innovation was introduced. The third edition, dated from 2005 (Oslo Manual 2005), considers four categories of innovation: product, process, organizational and marketing. It must be noted that the product innovation sector goes far beyond the technological dimension. A product is defined as goods or a service, so there are many products that have no technological form and are expressed in the form of services (e.g. services related to information, training, persons and goods). The economic importance of innovation in services is increasingly recognized (Davies &Buisine 2018). In the fourth edition, updates have been done in order to take into account a broader range of innovation-related phenolmena as well as the experience gained from recent rounds of innovation surveys in OECD countries and partner economies and organizations (Oslo Manual 2018).

The theoretical concepts of foreign scientists are of interest and importance, in particular the ones by Levitt who offered the idea concerning some discussions about innovation and imitation. He (1966) stated that no business could afford to even try to be the first in everything in its field and that the use of imitation was one of its survival strategies and growth. According to Levitt, innovation is not the greatest source of novelty at all (1966). He was referring to the fact that when competitors in the same industry copy the innovator (a given firm or industry that has released what is an absolute know-how), they become part of the innovation process (Levitt 1966).Abrams (1971) argued that imitation is only a mean for the creation of goods. Urabe (1988, p.3) said:

> "innovation consists of the generation of a new idea and its implementation into a new product, process or service, leading to the dynamic growth of the national economy and the increase of employment as well as to a creation of pure profit for the innovative business enterprise. Innovation is never a one-time phenomenon, but a long and cumulative process of a great number of organizational decision-making processes, ranging from the phase of generation of a new idea to its implementation phase."

Discussions about the nature, determinants, types, and effects of innovation are very active and widespread among scholars in all fields of activity.

Innovations have certain common classification features that assume their key role in the process of changing and implementing new combinations of existing and new knowledge. In the writings (Romer 1990, Rivera-Batiz & Romer 1991) the issues of the impact of innovations on market economy are actualized. In particular, these authors showed through simulation that technical progress for the country's economy is provoked by endogenous factors and they integrated technological innovation into a long-term economic analysis. These works are of significant interest for domestic researches in terms of updating and focusing on endogenous factors of impact on innovative development of enterprises and can serve as the basis for forecasting the development of industry in the regions of Ukraine and economy in general. But, in general, the concept of innovation is rather complex and multifaceted. Despite many studies, the generally accepted definition of innovation in science does not exist (Kogabayev& Maziliauskas 2017).

Nowadays, the world's economies face severe challenges concerning unstable political situations, military conflicts, unemployment, inflation, declining indices of industrial development, rapid scientific and technological progress, and globalization processes. These can

result in negative impacts on the enterprise competitiveness. The inability to define the complexity of the real world, all of its systems and organizations, plus changing dynamics of the system, and its relationship with the players, put the researcher in a position of uncertainty for the prediction of events in a complex system within a time frame (Argentine-German Chamber of Industry and Commerce 2009).

Generalized definitions of innovation applicable in all economic sectors of the System of National Accounts (SNA) to support international comparison of innovation in each sector, as well as monitoring and evaluation of innovation policies that have been implemented are proposed in Gault (2016). The notion and concepts of innovation activity in the Ukrainian literature became actively used only during the period of transition to market economy. By that time, the concept of scientific and technological progress was used, and some issues of innovations were developed only within the limits of economic achievements and the necessity of introduction of new technology into production and military sphere in Ukraine and the Soviet Union in general.

In the paper (Khariv & Mykytiuk, 2014) it was proven that one of the factors which slow down the innovation development of Ukrainian enterprises is the lack of financial resources. In the paper (Khariv *et al*., 2015), the authors explore the condition of innovative and technological development of enterprises of the western region of Ukraine and provide suggestions for ensuring their competitiveness in unstable environment. However, in the writings of Khariv *et al*. (2015), no attention was paid to determining the correlation between the amount of expenses on innovation activity of industrial enterprises and Ukraine's GDP. In the article (Hladynets, 2014),the forecast of innovation activity using economic and mathematical methods was carried out. However, this forecast was extrapolated and implemented only for a short period of time (3 years), which will not make it possible to strategize on enterprise's development in the short and long term.

Characteristic features of innovation activity of industrial enterprises which are of interest in terms of their forecasting, are presented in the work of Rosokhata (2014). Suggestions on the methodology of perspective directions forecasting of innovative development are given in the paper. But issues related to the definition of events with the finite number of possible finals, in which future depends on the current state but does not depend on the past are unresolved.

The dependence of industry's efficient functioning on innovation activities has been proven by Ilyash, Dzhadan and Ostasz (2018). The mathematical model of correlation between the industrial products' revenue and the indices of innovation activities of the Ukrainian industry was developed in the article. The impact was modeled of the increase in financing innovation activities by 1 hryvnia (UAH) on the increase in industrial products' revenue, the impact of the increase in the introduction of new technological processes by 1 unit on the increase in the revenue of industrial products, and the increase in the development of innovation types of products by 1 unit on the increase in volumes of sold industrial products for 2005-2016. The obtained results of analyzing innovation development indices made it possible to determine the degree of influence on the index of revenue of industrial products, where the most influential factor was financing innovation activities and the least influential – introduction of new technological processes. But it is expedient to determine the correlation between expenditures on innovation activity of industrial enterprises and gross domestic product (GDP) of Ukraine in actual prices, as well as to forecast the total amount of the expenditures on innovation activities of industrial enterprises. It should be noted that

almost no attention is paid to the forecasting method of economic and social processes by Markov chains with discrete states in the scientific researches of domestic and foreign scientists, which is the basis of the research presented in this paper.

## 3. METHODOLOGY

Data for GDP and FDI into Ukrainian economy are provided by the State Statistics Service of Ukraine. All data cover the period of 2010-2017, while forecast is carried out for 2018-2025. The forecast of financing innovation activities of industrial enterprises is made with the use of the theory of Markov chains. A Markov chain is a sequence of random events with a finite or countable number of outcomes, characterized by the property that, with a fixed present, future is independent from the past.

The random process occurring in the system S is called the Markov process. For every time $t_0$ the probability of any state of the system in future (for $t > t_0$) 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, the future state of the system depends on the present and does not depend on its "pre-history". But the Markov random process (Markov chains) with discrete states is the most interesting for economic forecasting. In that case we assume that for each condition of the system, the probabilities of transitioning to another condition at one step are known. We will mark the probability of transition of system S from the condition "i" to the condition "j" over a period of time from $t_0$ to t by $p_{ij}$. Let system S have "n" possible conditions $S_1$, $S_2$, ... $S_n$, then we will introduce the transition probabilities $p_{ij}$ in the form of the transition matrix ||pij||:

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

In other words, applying the theory of Markov chains for economic processes forecasting the present state of the country`s economy is taken into account and the vector of strategic economic development is imposed, that is, the system goes into another state gradually, step by step.

The sum of all elements of each line of the matrix is equal to 1. That is, for a time interval "t" the Markov chain will necessarily transform from the condition "i" into one of the admissible conditions "j" (Rohatynskyi & Garmatiy 2015).

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

The square matrix $\|p_{ij}\|$ of input indicators for investments and the sales volume of Ukrainian industrial products will be considered as the stochastic one, since all its elements are not negative and the sum of all elements of each line of the matrix is equal to 1. In addition to the matrix of transition probabilities, it is necessary to have the vector of the initial condition of the $p_i$ system to completely specify the Markov chain. Vector-line $p_i$ is a probabilistic vector. All elements of the vector are non-negative, and the sum of the elements is equal to 1, that is:

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

The initial condition of the system can be set using a probabilistic vector-line, one of its elements is equal to 1 and all other elements are equal to 0.
It is proved that the probability vector of the Markov chain at time "t" equals the product of the probability vector at the initial moment "$t_0$" and the transition matrix, that is:

$$p_{(t)} = p_{(t_0)} * \|p_{ij}\| \quad (4)$$

Methodology of applying the theory of Markov chains for economic processes is quite new and allows taking into account the stochastic and discrete phenomena occurring in the socio-economic world. It is worth mentioning

that classical methods of forecasting based on extrapolation or expert methods do not consider the elements of randomness. Most economic and social processes develop as the casual ones under the influence of some factors. It is necessary to construct a probabilistic model in order to predict the future state of these processes (Rohatynskyi & Garmatiy 2015).

In order to understand future processes and to adjust the strategy of Ukraine's economic development in terms of implementing investment resources, the forecast of investment indicators and volume of sold products by industrial enterprises of Ukraine for 2010-2017 was carried out in the MATLAB software, a program evaluation instrument for economic-mathematicalmodeling implemented in modern information systems.

## 4. EMPIRICAL RESULTS AND DISCUSSION

### 4.1. Technological and industrial development of Ukrainian economy and experience of neighboring countries in attracting FDI

By the level of technology, the Ukrainian industry is one third behind the EU indicators. The share of high-tech production in exports lags behind four to eight times, and energy efficiency lags behind ten times. Due to introduction of new technologies, GDP growth is 0.7%. Over the years of Ukraine's independence, new types of equipment have decreased by 14.3 times, and the share of innovation-active industrial enterprises has decreased by five times (Zhmierienietskii 2017; World Bank). In 2014, there was a significant acceleration of industrial production decline, which by the end of the year amounted to 10.2%. Negative dynamics was demonstrated by all major aggregate types of industrial activity: reduction of output in the extractive industry and the development of quarries was 13.7%, the processing industry – 9.3%, electricity, gas, steam and air conditioning supply – 6.6%. This trend was largely due to a downfall of production in Donetsk and Lugansk regions (31.5% and 42% respectively in 2014) at the territories where the anti-terrorist operation took place (IAC 2015).

After a decline of industrial production, which deepened during 2012-2015, in 2016 there was a growth of industrial production by 2.8%, which was mainly the result of the production growth (by 4.3%). In the extractive industry in 2016, compared to 2015, indices of industrial output declined by 0.2%. The highest growth rates among all industries in 2016 were recorded in the production of coke and refined products – 8.7%, but this was mainly due to the low base of comparison, since in 2015 industry fell by almost 20% (Sobkevych *et al*., 2017). At present, activities of the Ukrainian industrial enterprises are mainly focused on introduction of austerity, which is an effective way of survival under crisis but only in the short term (Fedyshyn, 2017).

Innovation directly affects GDP which is proved by the Bloomberg Innovation Index. It takes into account the intensity of research and development, the added value of manufactured products, productivity of the economy, and efficiency of the "tertiary" industry (implied in the intellectual and other industries). The top ten innovative countries, according to 2018 data, include South Korea, Sweden, Singapore, Germany, Switzerland, Japan, Finland, Denmark, France, and Israel. In the top 50, Ukraine was the worst in terms of economic productivity and was among the top three outsiders concerning industry profitability. Ukraine lost four positions compared to 2007, occupying the 46$^{th}$ place. Ukraine is ahead of Cyprus, South Africa, Iran, and Morocco. At the same time, it keeps a high 21$^{st}$ position according to the tertiary efficiency and the 27$^{th}$ position by its patent activity (Bloomberg 2018).

According to another annual survey – the Global Innovation Index, Ukraine's position is even worse: the 64th place between Serbia and the Seychelles (Kornyliuk & Kharlamov & Shyshatskyi 2016; Global Innovation Index 2018). A global survey of company executives in 2017 testified that half of the companies believe that innovation efforts have a significant effect on their revenue growth through sales growth. Every fifth innovation-leading company expects a 15.0% increase in revenue over the next five years after launching innovations (Zhmierienietskii 2017).

The experience of Poland testifies that in 2004 not all Polish companies (especially small and medium-sized enterprises) were able to overcome the competitive pressure from the EU member states and adapt to the EU standards. Coal and metallurgical enterprises were in a difficult situation due to high cost, low productivity, and non-compliance with the EU safety requirements. About 80 thousand Polish farmers stopped growing beetroot and five sugar factories were closed within the framework of the sugar industry reform in the EU in 2006-2009 (Doliwa-Klepacka &Doliwa-Klepacka 2008). Gdansk shipyard turned out to be in a tough condition, and Szczecinskaya was completely closed.

Poland received about 5 billion euro annually from the European budget, which is about 2% of the country's GDP. At the same time, Warsaw's contributions were less than half of these amounts. Thus, according to the Committee of European Integration by January 1, 2009, the Republic of Poland received EUR 26.5 billion, and membership fees totaled EUR 12.5 billion. This means that after four and a half years of membership the country received EUR 14 billion more than it paid to the joint budget (Kałużyńska, Smyk & Wiśniewski 2009). The balance of budget payments amounted to EUR 13.7 billion in 2009-2010. Warsaw received about EUR 12 billion from the Community funds during 2004-2006, while in 2007-2013 this amount was about EUR 68 billion. However, there are some difficulties. Government debt is increasing, imports exceed exports, some enterprises have not been able to overcome compe-tition and adapt to the EU standards. As a result of the implementation of the Common Agricultural Policy, the country is forced to restrain the development of agricultural production, and the level of support for Polish agrarians is much lower than in Western European countries. Significant outflow of labor led to a shortage of skilled workers (Lozhechkin 2012).

Romania has attracted more FDI since joining the EU, creating new jobs, witnessing economic growth, higher living standards, saving and investing, ensuring better customer protection and increasing competition, developping capital markets, *etc*. (Simionescu 2018). All these advantages have also helped to attarct foreign investors to Romania. Unlike other countries that have recently joined the EU, Romania and Poland reached the highest level of FDI inflows during the precrisis period (2005-2008). This result for Romania is explainned by Simionescuas an acceleration of privatization on the background of preparations for the EU integration and by the increased confidence of foreign investors. In 2008, Romania was the 10th EU country according to the attracted FDI volume. After the crisis, however, Romania has not remain-ned a country as attractive as Poland. The advantages of European economic integration for Romania are counterbalanced by fierce competition with firms in the old EU member states, the competitive pressures of the single market, and rapid technological change, which can bring unemployment in the short term as a result of the restructuring of businesses and sectors.

### 4.2 Analysis of the dynamics of industrial enterprise performance and foreign economic flows between Ukraine and the EU

The dynamics of indicators of FDI attracted from the EU into the real sector of the

Ukrainian economy is an important indicator of effectiveness of cooperation with the EU. Nowadays, the potential for attracting FDI from the EU countries is not enough. This results in the reduction of FDI accumulated in the Ukrainian economy from EU countries in 2016 by 1.2% – from US$ 26.4 billion by January 1, 2016 to US$ 26.1 billion by December 31, 2016. Industry was the most interesting for investing among all spheres of the real sector. However, in 2016, its investment by EU countries decreased by 6.4%. The key European investors in the Ukrainian industry with a total share of 69.3% were Cyprus (24.3% of the FDI accumulated in industry), the Netherlands (19.3%), Germany (10.5%), Austria (2.7%), Poland (2.7%), Luxembourg (2.3%), and Sweden (2.2%). It should be noted that in recent years there has been a significant reduction in FDI from Germany, which has been a leading investor for the Ukrainian industry for many years. This is due to the fact that the majority of German investments were concentrated in the Ukrainian metallurgy enterprises, a large part of which were located in the temporarily occupied territories, while other industries faced significant losses from the breakdown of technological and industrial ties with the non-controlled territories (Sobkevych *et al*., 2017).

The analysis of the dynamics of foreign economic flows between Ukraine and the EU testifies of a number of negative trends, including reduction of total investments from EU countries into the Ukrainian industry and agrarian sector; deterioration of the geographical structure of FDI in industry due to the reduction of Germany's share and the exit of offshores (Cyprus, partly the Netherlands); subordination of foreign trade with the EU to the objectives of providing EU countries with Ukrainian primary goods and the use of Ukraine as a market for European high-tech products (Sobkevych *et al*., 2017).

Indicators of investments and amount of sold industrial production of Ukraine in 2010-2017 are presented in Table 4.1. More total amount of expenditures on financing innovation activity of industrial enterprises should lead to higher growth rates of the amount of sold innovative products. But this is not always the case.

With the increase of investments into industry during 2010-2017, the share of funds, addersed exclusively to innovation activity, varies considerably from year to year. Unfortunately, only UAH 9,117.5 million was spent on innovation activity of the total UAH 143,300.0 million invested in the Ukrainian industry in 2017. The amount of innovation products sold by industrial enterprises has a negative

Table 4.1 *Indicators of investments and amount of sold industrial production of Ukrainein 2010-2017*

| Year | Capital investment in industry, mln.UAH | Amount of sold industrial products, mln. UAH | Total amount of expenditures for financing innovation activity of industrial enterprises, mln. UAH | Amount of sold innovation products by industrial enterprises, mln. UAH | Share of sold innovation products in the amount of industrial products,% |
|---|---|---|---|---|---|
| 2010 | 55,384.4 | 1 043,110.8 | 8,045.5 | 39,638.2 | 3,8 |
| 2011 | 78,725.8 | 1 305,308.0 | 14,333.9 | 49,601.7 | 3,8 |
| 2012 | 91,598.4 | 1 367,925.5 | 11,480.6 | 45,141.5 | 3,3 |
| 2013 | 97,574.1 | 1 322,408.4 | 9,562.6 | 43,639.5 | 3,3 |
| 2014 | 86,242.0 | 1 428,839.1 | 7,695.9 | 35,721.0 | 2,5 |
| 2015 | 87,656.0 | 1 776,603.7 | 13,813.7 | 24,872.5 | 1,4 |
| 2016 | 117,753.6 | 2 158,030.0 | 23,229.5 | - | - |
| 2017 | 143,300.0 | 2 625,862.7 | 9,117.5 | 18,381.0 | 0,7 |

Source: State Statistics Service of Ukraine

tendency of decrease from 2011 to 2017. During the analyzed period, the share of sold innovation products in the total amount of industrial production sharply decreased annually. The dynamics of Ukraine's GDP (in actual prices) in 2013-2017 is provided in Table 4.2.

Table 4.2 *Ukraine's GDP (in actual prices) for the period of 2013-2017.*

| Year | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Ukraine's GDP (in actual prices), mln. UAH | 1,465.198 | 1,586.915 | 1,988.544 | 2,385.367 | 2.983,882 |

Source: State Statistics Service of Ukraine

Ukraine's GDP (in actual prices) for the period from 2013 to 2017 showed the tendency to increase. A toolkit that takes into account randomness and unpredictability in the ability to implement investment policy, took into account quite significant endogenous and exogenous factors including political situation in the East of Ukraine, investors' desire to invest in the national economy, its slow reformation, as well as the desire and ability of modern business managers to innovate, which affect both the total expenditures for financing innovation activities of industrial enterprises and Ukraine's GDP. Thus, the expenditures for innovations of the national economy were stochastic.

### 4.3. Simulation and forecast of the total amount of expenditures for financing innovation activities of industrial enterprises in Ukraine

On the basis of correlation-regression analysis and using MATLAB software, a correlation between the matrix "total amount of expenditures for financing innovation activities of industrial enterprises" (Table 4.1) and the matrix "Ukraine's GDP in actual prices for the period of 2013-2017" (Table 4.2) is estimated. For doing so a matrix of GDP values is specified:

```
>> Z=[1465 1587 1989 2386 2983]

Z =

1465    1587    1989    2386    2983
```

The input matrix of the amount of financing expenditures is determined as:

```
>> A=[9563 7696 13814 23230 9118]
```

The correlation using the "corrcoef" function of the MATLAB software is estimated:

```
>> corrcoef (A,Z)

ans =

1.0000   0.2676
0.2676   1.0000
```

Thus, the calculations testify that the correlation density of the link between indicators is significant and is equal to 1, that is, if there is a positive dynamics of financing innovation activity of industrial enterprises, accordingly, there will be the positive dynamics of Ukraine's GDP.

To carry out the forecast, the data of Table 1 are presented in the matrix form.

The matrix of the input data of the total amount of expenditures for financing innovation activity of industrial enterprises for the period from 2013 to 2017 is as follows:

```
>> A=[9563 7696 13814 23230 9118]

A =

- 9563   7696   13814   23230   9118
```

The estimated amount of financing for 5 years would be: 63421

```
>> B=[63421 63421 63421 63421 63421]

B =

63421   63421   63421   63421   63421
```

The ratio of expenditures of each year to the total expenditures:

```
>> rdivide(A,B)
ans =
0.1508  0.1213  0.2178  0.3663  0.1438
```

The matrix of transitions will be as follows:

```
>> C=[0.15080.1213 0.2178 0.3663 0.1438;0.12130.2178 0.3663 0.1438 0.1508;0.2178 0.3663 0.1438 0.1508 0.1213;0.3663 0.1438 0.1508 0.1213 0.2178;0.1438 0.1508 0.1213 0.2178 0.3663]
C =
0.1508  0.1213  0.2178  0.3663  0.1438
0.1213  0.2178  0.3663  0.1438  0.1508
0.2178  0.3663  0.1438  0.1508  0.1213
0.3663  0.1438  0.1508  0.1213  0.2178
0.1438  0.1508  0.1213  0.2178  0.3663
```

It is assumed that at the initial time (2017) the system will be in the condition $S_0$. Probability of condition $p_{(0)} = 1$. The vector of the initial condition of the system is written as $p_{(0)} = [0\ 0\ 0\ 0\ 1]$.

```
>> p=[0 0 0 0 1]
p =
0   0   0   0   1
```

The state of the system until the condition stabilizes is determined as:

```
>> p1=[p*C]
p1 =
0.1438  0.1508  0.1213  0.2178  0.3663
>> p2=[p1*C]
p2 =
0.1989  0.1813  0.1813  0.1989  0.2397
>> p3=[p2*C]
p3 =
0.1988  0.1948  0.1948  0.2026  0.2090
>> p4=[p3*C]
p4 =
0.2003  0.1986  0.1986  0.2003  0.2023
>> p5=[p4*C]
p5 =
0.2000  0.1996  0.1997  0.2002  0.2006
>> p6=[p5*C]
p6 =
0.2000  0.1999  0.1999  0.2000  0.2001
>> p7=[p5*C]
p7 =
0.2000  0.1999  0.1999  0.2000  0.2001
>> p8=[p7*C]
p8 =
0.2000  0.2000  0.2000  0.2000  0.2000
```

The results of simulation are presented in Table 4.3.

Table 4.3 *The results of simulation and forecast of the amount of expenditures for financing innovation activity of industrial enterprises for the period of 2018-2025*

| Year | Probabilistic conditions of the predicted system (p) | | | | |
|---|---|---|---|---|---|
| | P1 | P2 | P3 | P4 | P5 |
| 2018 | 0.1438 | 0.1508 | 0.1213 | 0.2178 | 0.3663 |
| 2019 | 0.1989 | 0.1813 | 0.1813 | 0.1989 | 0.2397 |
| 2020 | 0.1988 | 0.1948 | 0.1948 | 0.2026 | 0.2090 |
| 2021 | 0.2003 | 0.1986 | 0.1986 | 0.2003 | 0.2023 |
| 2022 | 0.2000 | 0.1996 | 0.1997 | 0.2002 | 0.2006 |
| 2023 | 0.2000 | 0.1999 | 0.1999 | 0.2000 | 0.2001 |
| 2024 | 0.2000 | 0.1999 | 0.1999 | 0.2000 | 0.2001 |
| 2025 | 0.2000 | 0.2000 | 0.2000 | 0.2000 | 0.2000 |

Source: State Statistics Service of Ukraine

According to the forecasting model of the total amount of expenditures for financing innovation activityof industrial enterprises based on the data for the period of 2013-2018, it can be concluded that financing of innovation activity of industrial enterprises will stabilize only in seven years – in 2025. We may state that this period is too long for the Ukrainian industry to develop.

The analysis of the experience of foreign countries (in particular Poland and Romania) made it possible to point out some difficulties concerning adaptation of industrial enterprises in the process of European integration. The Ukrainian situation is complicated by the military conflict in the East of the country, unstable economic situation, high levels of corruption, inefficiency and, obviously, inappropriate use of funds for modernization and development of industrial sector of the economy. Since industrial production represents the main share in the structure of the country's GDP, it should keep up with time and requires rapid renewal of fixed assets, rapid integration of scientific researches and developments into production process, and production of innovative competitive products.

Concerning improvement of investment and innovation activity of industrial enterprises in the forecast period, we recommend the following measures to be undertaken:

- to identify priority areas and develop a strategy for industrial development;
- to monitor exogenous and endogenous factors on the investment climate;
- to constantly evaluate the market situation due to the fact that innovation that successfully passed the stage of testing and production may not be accepted by the market and its production can be suspended;
- to plan and finance applied researches; for doing so it is important to create conditions for the joint development of applied researches and higher educational institutions;
- to introduce new innovative technologies and products on the basis of applied developments;
- to bring in effective patents for inventions;
- to carry out analysis and forecast of new product life cycle, as it happens that the life cycle of technology changes in time more often than the demand;
- to diversify production on-time;
- to improve the innovation management system;
- not to tear away scientific developments from the needs of industry;
- to create and support technological clusters.

These activities are major and extremely important for Ukrainian enterprises nowadays and they need to be implemented as quickly as possible in order to stabilize investments and inject funds into domestic industry. The use of modern economic and mathematical tools makes it possible to study the financial and economic indicators at both macro- and micro- levels deeper. The forecast of financial factors will allow to adjust the strategy of the national economy development.

The conducted researches have testified that the forecasting of indices of investment-innovation activity should be carried out on the basis of system approach, targeting, and goal-oriented result, taking into account the hierarchy of goals on the basis of economic and mathematical methods.

## 5. CONCLUSION

In 2014-2018, the socio-economic development of Ukraine was characterized by a decrease of industrial production in most regions, the outflow of investment capital, suspension of investment and innovation projects, and unsustainable export dynamics. The analysis of the dynamics of foreign economic flows between Ukraine and the EU testifies of a number of negative trends, including reduction of total investments from EU countries into the Ukrainian industry and the agrarian sector; reduction of the EU share

in the structure of the total FDI into industry; deterioration of the geographical structure of FDI with the EU in industry due to the reduction of Germany's share, and the exit of offshores (Cyprus, partly the Netherlands) on the leading positions in the volume of investments attracted to industry; subordination of foreign trade with the EU to the objectives of providing EU countries with Ukrainian primary goods, and the use of Ukraine as a market for European high-tech products (Sobkevych *et al*., 2017).

The research on the basis of correlation-regression analysis between such financial factors as the total amount of expenditures for financing innovation activity of industrial enterprises and Ukraine's GDP in actual prices for 2013-2017 made it possible to estimate a sufficiently strong correlation between these indicators (the correlation coefficient is 1). This indicates that the positive dynamics of the increase in the total amount of expenditures for financing innovation activities of industrial enterprises will lead to the positive dynamics of Ukraine's GDP, which in turn will improve almost all indicators of the national economy's industry.

A practical value of this research is the application of a forecasting methodology on the basis of the Markov chain theory. It solves the consideration of stochastic factors of influence on financing innovation activitythat occur in economies, including political instability, natural disasters, change of social and economic system of the country, and other random processes that are not taken into account when applying classical methods of forecasting and estimating the prospects of country's economic development. The use of modern programming platforms allowed to make a conclusion that stabilization of the situation concerning financing innovation activity in Ukraine with the highest probability will take place in six years – in 2025.

The forecast presented in the paper makes it possible to monitor the financing of innovation activity of Ukraine's industrial enterprises and to make adjustments to possible increase of capital investments into economic activity.

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