Digitization of Investment-Innovation Development of Ukrainian Economy: Empirical Analysis

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Abstract. This article reveals the principles of research of investment-innovation development of the country in terms of digitization of the economy, which will lead to economic growth and increase the country’s competitiveness on the world market. The article reveals the global trend of digitization, analyzes approaches to digitization, identifies the place of information and communication and digital technologies at the current stage of economic development, and focuses on the need of digital transformation of Ukraine. The authors focus on the multifaceted processes of digitization and digital transformation of the world’s economies. Current trends of digital transformation of the world’s economies and various processes have necessitated this study. In particular, the authors pay more attention to the digitization of investment-innovation development of Ukrainian economy on the basis of empirical analysis. The role and importance of foreign direct investments and the need of financing innovations in the digital transformation of Ukraine’s economy to accelerate economic growth and increase global competitiveness are proved. Based on the analysis of works of domestic and foreign scientists, author’s research and generalization of world economic development trends and Ukraine’s for the last twenty years, the leading place of foreign direct investments and innovations in transformation processes that promote rapid economic growth have been proved. The econometric model constructed by the authors showed the relationship between macroeconomic factors (GDP, foreign trade, inflation and employment) and their influence on investment-innovation development in terms of digitization of economy.

Keywords: Digitization / Globalization / Information economy / Information and digital technology / Foreign direct investments / Innovations / Economic growth

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1 Introduction

The process of integration of Ukraine to the world community involves the development of investment-innovation activity of society, which radically changes economic, technological, social, organizational and other terms of this process and determines the competitiveness and stability of the country taking into account current global trends. Processes of globalization, scientific-technical and technological revolution, the dynamic development of information and communication technologies determine the importance of the need of digital transformation of Ukraine’s economy, including investment-innovation development.

The purpose of our research is to identify changes of determinants of investment-innovation development of the country in terms of digital transformation as a general trend of further development of world economy. Based on this goal, the main tasks are to research the basic principles of digitization of the country and to identify its influence on the process of attracting foreign direct investments and the costs on innovations in the economy on the example of Ukraine.

The novelty of research in the presented article is the substantiation and econometric testing of functional relationships between the attraction of foreign direct investments and realization of costs on innovations and important macroeconomic indicators of the national economy. This approach will provide a more objective understanding of interdependencies between external and internal factors of development of Ukraine’s economy and will form methodological bases for expert assessment in substantiating the priorities of digital and investment-innovation development in terms of global challenges of the XXI century.

Theoretical and applied aspects of digital transformation and development have been revealed in the works of famous Ukrainian scientists, such as Bilyk O [1], Dulskaya I. [2], Kraus N. [3], Rudenko M. [4], Fedulova L. [5] and others. The analysis of scientific works prepared by these authors showed that they paid attention to the digital transformation of the world’s economies; to the processes of production and provision of services, which are one of the leading trends; to the issues of identifying the main drivers of digitization of the economy and their importance for social development; to the peculiarities of high-tech development in terms of globalization, the need for the introduction of digital technologies, which will contribute to the realization of the synergetic effect and economic growth.

Important achievements in the research of digitization of economy have made foreign scientists, the last of which are Stjepić A.-M. and et al [6], Isaacson W. [7], Grimes A. [8], Grabis J. [9], Niebel T. [10], Chinese researchers such as Young-Chan Kim and Pi-Chi Chen [11], etc.

Thus, digitization is of great importance, which is a tool for economic growth, increasing the competitiveness of investment-innovation sphere, creating new jobs and improving the lives of the population. That is why the authors prove the relevance of the digital transformation of Ukraine’s economy and its influence on investment-innovation development. The role of foreign direct investments (FDI) in the digital economy, the determinants of attracting investments in the national economy and
factors influencing on the level of costs on innovations are identified based on econometric modeling, using E-Views program.

2 Materials and Methods

An active phase of world development today is the global trend of digitization. Developed countries are successfully digitizing their economies, giving preference to innovative technologies, including digital platforms. The XXI century, which is characterized by rapid changes, has actualized the field of digitization, which is caused by the rapid development and spread of information-communication and digital technologies. Versatility and debatability of some issues related with digitization and digital transformation lead to further research of the impact of information-communication and digital technologies on economic development. Theories of information-communication and digital technologies have been studied by D. Bell [12], Castells M. and Himanen P. [13], A. Toffler [14], Wallerstein I [15] and others. In their researches, they revealed the principles of information economy formation, determined the role and influence of information-communication and digital technologies on economic development.

Consulting company (USA) Gartner, which specializes on information technology markets, defines digitization as “the use of digital technologies to change a business model and provide new revenue and value-producing opportunities” [16]. This definition focuses on changing business models and does not cover all areas of public life and economic development of the country. American scientists J. Scott Brennen and Daniel Kreiss consider digitization as “the way in which many domains of social life are restructured around digital communication and media infrastructures” [17]. Digital transformation is a broader term than digitization. This term includes strategic transformation and introduction of information-communication and digital technologies [18]. According to the authors’ views, digitization of the economy involves the creation of information and digital platforms by disseminating information-communication and digital technologies, which will solve more quickly and effectively strategic tasks.

In Ukraine, the need to form a digital economy and society is recognized at the state level, and digital technologies are considered as one of the key drivers of sustainable development [19]. The rapid and profound consequences of the transition to the digital economy will be possible only when digital transformation becomes the basis of life of Ukrainian society and economy, becomes a commonplace and everyday phenomenon, will be “our key agenda on the path to prosperity and the basis of well-being of Ukraine” [20]. The development of the national economy, modernization of existing technologies, digitization necessitate structural reforms.

Innovative technologies require large volumes of financing and investments. For Ukraine, whose economy has lack of national investments the question of attracting FDI is acute [21].

To achieve the setted goal it is necessary to research the current stage of digital transformation and current trends of national economy development; identify factors
influencing the digitization of investment-innovation development; prove the importance of FDI and innovations for economic growth; using the econometric model to show the influence of the most significant factors on the volume of FDI attractions and investing in innovations and to prove their influence on growth in terms of digital transformation of the economy.

Due to the digital transformation, it becomes possible to develop innovations more rapidly, support startups, teach everyone the basics of programming and implement digital technologies in the field of economics. However, according to experts of The Boston Consulting Group by 2020, about 25% of the world economy will move to the introduction of digital technologies that allow government, business and society to function more efficiently and 16% of job losses [22].

Our hypothesis is that in terms of digital transformation of the Ukrainian economy the role and necessity of attraction of FDI and realization of bigger volumes of innovations grows; so, with the help of econometric modeling we will check the influence of exogenous and endogenous macroeconomic factors on investment-innovation development.

This study is based on authors’ empirical analysis for the period 1999-2018 of economic development of Ukraine. This approach made it possible to identify those factors that have the greatest influence on investment-innovation development of the country in the era of digital globalization. Factors that affect the quantitative value of investment-innovation development (the volume of attracted FDI and volume of costs on innovations) are: GROWTH, FT, I, LM. The general view of such model illustrates the relationship of selected factors and is described by the following equation:

\[ \text{FII}(\text{FDI} + \text{SI}) = F(\text{GROWTH}, \text{FT}, \text{I}, \text{LM}) \]

Where,
- FII = the sum of attracted foreign direct investments in the economy of Ukraine and the costs made on innovations, mln. USD;
- GROWTH = Growth represents National economic growth measured by the growth rate of real Gross Domestic Output (Ukraine’s GDP), mln. USD;
- FT = foreign trade of goods and services of Ukraine, USD mln. (export, import);
- I = inflation index for the year;
- LM = employed population, million people.

The authors built a multifactor regression model based on statistical data for the last two decades. The hypothesis concerning the influence of selected factors on the investment-innovation development of the country in the modern terms of economic digitization is tested with the use of software product E-Views. The absence of autocorrelation and heteroskedasticity was checked using various tests, the high quality of this model was proved, and the causal relationships between the selected factors were investigated using the Granger test.

However, it should be noted that authors used data before the current situation related to Covid-19, which may make adjustments to the economic development of the country. Such a “Black Swan” will make significant adjustments to the modern
economic development of the world. We consider a faster transition to online technologies in most spheres of society as a positive consequence, in particular, revenues will increase in e-Commerce, pharmaceuticals, delivery services, etc; the negative consequences are projected in the near future to fall world GDP (in particular, according to JP Morgan - the loss will be $5.5 trillion by the end of 2021 [23]), loss of production, declining consumer demand, expected decline in revenues.

3 Results

Digitization of investment-innovation development involves the use of modern technologies to increase the volume of FDI and investments in innovations [24]. To build the model, we analyzed statistics for the last twenty years, such as the volume of foreign investment in Ukraine, the costs made on innovation (excluding foreign investors), GDP, exports and imports of goods and services, the rate of inflation and the rate of employed population [25]. Let’s check how the factors we choose influence on the amount of FDI and investments in innovations. The authors constructed a correlation matrix (Table 1).

Table 1. Correlation matrix of selected variables

|       | FII  | GROWTH | FT    | I      | LM    |
|-------|------|--------|-------|--------|-------|
| FII   | 1    | 0.1653 | 0.8397| 0.03352| -0.6635|
| GROWTH| 0.1653| 1      | 0.2766| -0.1981| -0.0774|
| FT    | 0.8397| 0.2766 | 1     | -0.1301| -0.3443|
| I     | 0.0335| -0.1981| -0.1301| 1      | 0.0019 |
| LM    | -0.6635| -0.0774| -0.3443| 0.0019 | 1      |

Source: authors’ development

Table 1 presents a correlation matrix that explains the relationship between selected variables and shows their influence on foreign direct investments and incurred costs for innovations. Matrix constructed by us confirms the success of the model. The correlation matrix of variables shows a strong correlation between attracted foreign direct investments and the costs made on innovations and foreign trade - 84%; negative correlation (66%) between FII and the employed population (66%) and the presence in the model of a negative correlation between other variables. In general, an acceptable result of the correlation between variables actually confirms that our model is successful. The results of multifactor regression are shown in Table 2.
Regarding the quality requirements of variables, we will apply the accepted average of 5-10% of the significance level. According to Fisher’s F-statistics, all the coefficients of the regression equation simultaneously are not equal to 0. In our equation, foreign trade and the employed population are less than 5%; therefore, these factors are the most significant. As a rule, there are no strict requirements for the constant, in our case it is also not significant (more than 5-10%). The variables GROWTH (GDP) and I are insignificant because their probability is more than 10%.

R2 shows the extent to which the selected variables and their quantity explain investment-innovation development, which the authors statistically examine through the amount of FDI attracted to Ukraine and investments made in innovations. In the author’s model, the researched variables explain the investment-innovation development of Ukraine by 88.2%; adjusted R-squared is 85%.

The presence of a sufficiently strong correlation indicates a correlation coefficient, which is 0.88; F-statistic = 0.000001, the probability of accepting the null hypothesis, confirms the need to take an alternative hypothesis, which certifies the significance of the equation as a whole.

We check the higher-order autocorrelation using the Breusch-Godfrey test. The idea of this test is as follows: if there is a correlation between adjacent observations, then we should expect that in the equation:

$$e_t = \rho \cdot e_{t-1} + \nu_t, \ t = 1, \ldots, n,$$

where $e_t$ – the regression residue obtained by the usual least squares method; coefficient $\rho$ - will be significantly different from zero.

### Table 2. The results of multi-factor regression

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|-------|
| GROWTH  | -0.007656   | 0.016551   | -0.462595   | 0.6503|
| FT      | 0.280631    | 0.038253   | 7.336194    | 0.0000|
| I       | 21131.13    | 16048.06   | 1.316740    | 0.2077|
| LM      | -3584.295   | 812.2249   | -4.412934   | 0.0005|
| C       | 43745.64    | 25921.55   | 1.687617    | 0.1122|

R-squared | 0.881596 | Mean dependent var | 26690.03
Adjusted R-squared | 0.850021 | S.D. dependent var | 18405.75
S.E. of regression | 7128.008 | Akaike info criterion | 20.79377
Sum squared resid | 7.62E+08 | Schwarz criterion | 21.04270
Log likelihood | -202.9377 | Hannan-Quinn criterion | 20.84236
F-statistic | 27.921200 | Durbin-Watson stat | 2.258566
Prob(F-statistic) | 0.000001 | Source: authors’ development

Table 2 shows the results of multi-factor regression using the least squares method and different coefficients, which as a whole prove the significance of the equation.
The results of the test are shown in Table 3. We check with the help of diagnostics: at lag 2, the probability of accepting the null hypothesis is much greater than 0.05, which means that this lag is not significant. At lag 1, at 5% significance level, the probability of accepting the null hypothesis $RESID \ (−1) = 0.6393$ and $RESID \ (2) = 0.8919$, which is more than 5%, and means that we can accept the null hypothesis of no autocorrelation, i.e. no autocorrelation. The probability of accepting the null hypothesis is 86%, i.e. we claim that in our model there is no autocorrelation of random deviations.

Table 3. Breusch-Godfrey serial correlation LM test:

| Variable     | Coefficient | Std. Error | t-Statistic | Prob. |
|--------------|-------------|------------|-------------|-------|
| GROWTH       | 0.000620    | 0.017620   | 0.035210    | 0.9724|
| FT           | -0.000680   | 0.040803   | -0.016667   | 0.9870|
| I            | 1747.407    | 18036.44   | 0.096882    | 0.9243|
| LM           | -150.3835   | 988.6197   | -0.152115   | 0.8814|
| C            | 871.3210    | 30440.79   | 0.028623    | 0.9776|
| RESID(-1)    | -0.150210   | 0.313075   | -0.479790   | 0.6393|
| RESID(-2)    | 0.043524    | 0.313926   | 0.138645    | 0.8919|
| R-squared    | 0.022836    | -6.34E-12  |             |       |
| Adjusted R-squared | -0.428163 | S.D. dependent var | 6333.402 |
| S.E. of regression | 7568.781 | Akaike info criterion | 20.97067 |
| Sum squared resid | 7.45E+08 | Schwarz criterion | 21.31917 |
| Log likelihood | -202.7067 | Hannan-Quinn criter. | 21.03870 |
| F-statistic  | 0.050634    | Durbin-Watson stat | 2.029886 |
| Prob(F-statistic) | 0.999252 |             |             |       |

Source: authors’ development

Table 3 shows the presence or absence of autocorrelation.

Let’s analyze the information criteria Akaike, Schwarz, Hannan-Quinn, Durbin-Watson. Criteria Akaike (20.79), Schwarz (21.04), Hannan-Quinn (20.84) are not significant, which confirms the success of the model. We check the equation for the presence of autocorrelation using the Darbin-Watson test ($d = 2.25$). From the Darbin-Watson statistics table, we determine the significant points $d_L$ and $d_U$. For the number of observations of 20 and 4 variables at a significance level of $\alpha = 5\%$ $d_L = 0.9$ and $d_U$
= 1.83; at 1% significance level $d_L = 0.68$ and $d_U = 1.57$. In our case, DW is greater than $d_U$, which means no autocorrelation.

We check the model for heteroskedasticity, using the following tests: Breusch-Pagan-Godfrey, Harvey, Glejser, ARCH, White and check the heteroskedasticity (non-constant variance) of random errors of the linear regression model. The test results are shown in Table 4, 5, 6, 7, and 8.

The probability of accepting the null hypothesis by the Breusch-Pagan-Godfrey test (Table 4) is 0.3926, which is more than 5% and confirms the absence of heteroskedasticity.

| Table 4. Heteroskedasticity test: Breusch-Pagan-Godfrey |
|---------------------------------|-----------------|-----------------|
| F-statistic                     | 1.099571        | Prob. F(4,15)   | 0.3926 |
| Obs*R-squared                  | 4.534714        | Prob. Chi-Square(4) | 0.3385 |
| Scaled explained SS            | 2.674106        | Prob. Chi-Square(4) | 0.6138 |

Test Equation: Dependent Variable: RESID^2
Sample: 1999 2018
Included observations: 20

| Variable   | Coefficient | Std. Error | t-Statistic | Prob. |
|------------|-------------|------------|-------------|-------|
| C          | -2.43E+08   | 2.04E+08   | -1.191828   | 0.2518|
| GROWTH     | -21.97924   | 130.0934   | -0.168950   | 0.8681|
| FT         | 587.8557    | 300.6744   | 1.955124    | 0.0695|
| I          | 1.13E+08    | 1.26E+08   | 0.898619    | 0.3831|
| LM         | 5124186.    | 6384210.   | 0.802634    | 0.4347|

R-squared   | 0.226736    | Mean dependent var | 38106378 |
Adjusted R-squared | 0.020532 | S.D. dependent var | 56611406 |
S.E. of regression  | 56027223 | Akaike info criterion | 38.73289 |
Sum squared resid   | 4.71E+16 | Schwarz criterion | 38.98182 |
Log likelihood      | -382.3289 | Hannan-Quinn criter. | 38.78149 |
F-statistic         | 1.099571 | Durbin-Watson stat | 1.758367 |
Prob(F-statistic)   | 0.392561 |

*Source: authors’ development*

*Table 4 shows the presence or absence of heteroskedasticity*

The Harvey test in Table 5 also shows the absence of heteroskedasticity, the probability of accepting the null hypothesis is 0.1539.
The following check for heteroskedasticity is by using the Glejser test for our variables (Table 6). All variable models were also tested separately by the test. All variables are not statistically significant, as the probability of accepting the null hypothesis is more than 5%, i.e., it can be accepted. The presence of regression in general is also high, i.e., in our model there is no heteroskedasticity, i.e., the model residues do not depend on the selected variables.

Table 5. Heteroskedasticity test: Harvey

| Test Equation: Dependent Variable: LRESID2 Method: Least Squares | Included observations: 20 |

| Variable   | Coefficient | Std. Error | t-Statistic | Prob. |
|------------|-------------|------------|-------------|-------|
| C          | 3.172557    | 10.67429   | 0.297215    | 0.7704|
| GROWTH     | -5.85E-06   | 6.82E-06   | -0.857891   | 0.4045|
| FT         | 3.51E-05    | 1.58E-05   | 2.225578    | 0.0418|
| I          | -3.658406   | 6.608464   | -0.553594   | 0.5880|
| LM         | 0.715873    | 0.334468   | 2.140334    | 0.0492|

| R-squared  | 0.342348    | Mean dependent var | 15.36130   |
| Adjusted R-squared | 0.166974 | S.D. dependent var | 3.216007   |
| S.E. of regression | 2.935257 | Akaike info criterion | 5.203785   |
| Sum squared resid | 129.2360 | Schwarz criterion | 5.452718   |
| Log likelihood  | -47.03785  | Hannan-Quinn criter. | 5.252379   |
| F-statistic    | 1.952104   | Durbin-Watson stat | 2.044076   |
| Prob(F-statistic) | 0.153939 |                           |            |

Source: authors’ development

Table 5 shows the presence or absence of heteroskedasticity
Table 6. Heteroskedasticity test: Glejser

|                     | F-statistic | Prob. F(4,15) | Prob. F(4,15) |
|---------------------|-------------|---------------|---------------|
| Obs*R-squared       | 6.008082    | 0.1985        |               |
| Scaled explained SS | 5.671248    | 0.2251        |               |

Test Equation: Dependent Variable: ARESID Method: Least Squares
Sample: 1999 2018 Included observations: 20

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|-------|
| C        | -16942.15   | 14662.43   | -1.155480   | 0.2660|
| GROWTH   | -0.004867   | 0.009362   | -0.519876   | 0.6107|
| FT       | 0.053611    | 0.021638   | 2.477676    | 0.0256|
| I        | 5439.481    | 9077.529   | 0.599225    | 0.5580|
| LM       | 560.7568    | 459.4321   | 1.220543    | 0.2411|

R-squared       0.300404  Mean dependent var 4547.380
Adjusted R-squared 0.113845  S.D. dependent var 4283.102
S.E. of regression 4031.932  Akaike info criterion 19.65420
Sum squared resid 2.44E+08  Schwarz criterion 19.90313
Log likelihood   -191.5420  Hannan-Quinn criter. 19.70279
F-statistic      1.610237  Durbin-Watson stat 1.681205
Prob(F-statistic) 0.223173

Source: authors’ development

Table 6 shows the presence or absence of heteroskedasticity

The ARCH test (Table 7) also shows the absence of heteroskedasticity and the probability of accepting the null hypothesis.
Another test using the White test, which is universal. By value of accepting the null hypothesis, all variables are not statistically significant; in addition, prob. F = 68%, which indicates the absence of heteroskedasticity (Table 8).
The model is verified on explanatory capability, since it should accurately reflect FDI inflows using available independent variables (see Fig. 1). As can be seen from the graph, the fitted values (Fitted) have the same trends with actual values (Actual), so the model is fully acceptable under this criterion.

Table 8. Heteroskedasticity test: White

| F-statistic       | 0.766654 | Prob. F(14,5) | 0.6827 |
|-------------------|----------|---------------|--------|
| Obs*R-squared     | 13.64400 | Prob. Chi-Square(14) | 0.4766 |
| Scaled explained SS | 8.045819 | Prob. Chi-Square(14) | 0.8869 |

**Test Equation:**
Dependent Variable: RESID^2
Method: Least Squares
Sample: 1999 2018
Included observations: 20

| Variable       | Coefficient | Std. Error | t-Statistic | Prob.   |
|----------------|-------------|------------|-------------|---------|
| C              | 1.92E+09    | 1.09E+10   | 0.176764    | 0.8666  |
| GROWTH         | 80322.68    | 115039.3   | 0.698219    | 0.5162  |
| GROWTH^2       | -0.016848   | 0.019646   | -0.857574   | 0.4303  |
| GROWTH*FT      | -0.000751   | 0.102203   | -0.007351   | 0.9944  |
| GROWTH*I       | -84594.06   | 110139.1   | -0.768066   | 0.4771  |
| GROWTH*LM      | 1023.592    | 1400.684   | 0.730780    | 0.4977  |
| FT             | -87501.24   | 132810.4   | -0.658843   | 0.5391  |
| FT^2           | 0.020337    | 0.115164   | 0.176592    | 0.8668  |
| FT*I           | 96144.39    | 115707.1   | 0.830929    | 0.4439  |
| FT*LM          | -1300.350   | 1697.071   | -0.766232   | 0.4781  |
| I              | -4.62E+09   | 1.53E+10   | -0.301549   | 0.7751  |
| I^2            | -5.10E+08   | 4.54E+09   | -0.112256   | 0.9150  |
| I*LM           | 2.80E+08    | 3.06E+08   | 0.915547    | 0.4019  |
| LM             | 77673021    | 3.80E+08   | 0.204560    | 0.8460  |
| LM^2           | -9837937.   | 8373992.   | -1.174820   | 0.2930  |

R-squared 0.682200
Adjusted R-squared -0.207641
S.E. of regression 62211810
Sum squared resid 1.94E+16
Log likelihood -373.4369
F-statistic 0.766654
Prob(F-statistic) 0.682714

Source: authors’ development

Table 8 shows the presence or absence of heteroskedasticity
We check the model for predictive quality: we pay attention to the MAPE criterion. For each integrated risk indicator, an approach is defined that improves the minimum forecast error. In our case, the criterion MAPE = 29.66, which means acceptable (but not high) accuracy of the forecast (see Fig. 2).

The study of causal relationship between the selected variables and the inflow of FDI and the realization of financing for innovations was implemented using the Granger test. The idea of such test is as follows: if a change in variable A is the cause of
change B, then change A precedes change B; that is, that the primary A or B. The regression equation of the two hypotheses of the directions of causality is as follows:

\[ A_i = \alpha_0 + \sum_{i=1}^{n} \alpha_i B_{t-i} + \sum_{j=1}^{n} \beta_j A_{t-j} + \varepsilon_t, \]

where,

\( A \) and \( B \) – dependent and independent variables, respectively; \( \alpha_0, \alpha_i, \beta_j \) – coefficients calculated as a result of regression; \( \varepsilon_t \) – the final member of the regression; \( ii, j = 1, 2, ..., n \) – the time delay.

As a result of the Granger test, the null hypothesis A is tested and is not the cause of changes B. The criterion for accepting the hypothesis is Prob. (the value of the probability of accepting the hypothesis). At the same time, the opposite causal relationship is also checked. If two coefficients are statistically significant at the same time, the dependence is two-way, or feedback-dependent. The existence of a two-way causal relationship may mean the existence of a third variable, which is the real cause of the changes in the two variables considered in the equation. If two coefficients are statistically zero at the same time, there is no cause-and-effect relationship (this is possible even if there is a statistically significant correlation). The tests were performed for lags 2–6. The results of the test are shown in Table 9.

According to the results of the Granger test (Table 10) we make a number of generalized conclusions:

- during the first year, the employed population and the volumes of attracted FDI and innovations expenditures are in dynamic interaction. This suggests that, on the one hand, the employed population affects investments and innovations development, on the other hand, the situation with the volume of attracted FDI and investments in innovations determines the dynamics of the employed population (including the return of migrants);
- change of the employed population at a certain time (+5 years) affects the process of attracting foreign direct investments and increasing the costs for innovations, which in turn will contribute to the growth of national economy in the near future;
- unilateral orientation of the influence of the employed population from the second period (+5 years) also has an impact on inflation. Such influence will promote the growth of volumes of production output;
- with a delay in the future, foreign trade will affect the employed population, which indicates a growing trend in services sphere.

The general form of the multi-regression model of dependence of investment-innovation development of Ukraine from independent variables can be described by the following equation:

**Substituted Coefficients:**

\[ \text{FII} = -0.00765641794241 \times \text{GROWTH} + 0.280631482649 \times \text{FT} + 21131.1275458 \times \text{I} - 3584.29483973 \times \text{LM} + 43745.6381445 \]
Table 9. The results of Pairwise Granger Causality Test on cause-effect dependence for the period 1999-2018

| Null hypothesis | lag 2 (Obs 18) | lag 3 (Obs 17) | lag 4 (Obs 16) | lag 5 (Obs 15) | lag 6 (Obs 14) |
|----------------|---------------|---------------|---------------|---------------|---------------|
|                | F-Stat. | Prob. | Conclusion | F-Stat. | Prob. | F-Stat. | Prob. | F-Stat. | Prob. | F-Stat. | Prob. |
| 1 GROWTH does not Granger Cause FII | 0.042 | 0.958 | accept | 0.315 | 0.913 | 0.314 | 0.816 | 0.518 | 0.756 | 7.726 | 0.268 |
| FII does not Granger Cause GROWTH | 0.253 | 0.780 | accept | 0.183 | 0.904 | 0.676 | 0.629 | 1.039 | 0.499 | 6.577 | 0.289 |
| 2 FT does not Granger Cause FII | 2.617 | 0.110 | accept | 1.978 | 0.181 | 0.823 | 0.549 | 0.982 | 0.712 | 2.064 | 0.487 |
| FII does not Granger Cause FT | 0.328 | 0.725 | accept | 0.451 | 0.721 | 0.642 | 0.775 | 0.924 | 0.732 | 0.660 | 0.729 |
| 3 I does not Granger Cause FII | 2.225 | 0.147 | accept | 1.517 | 0.269 | 1.664 | 0.260 | 7.258 | 0.038 | 1.673 | 0.531 |
| FII does not Granger Cause I | 0.609 | 0.558 | accept | 1.304 | 0.326 | 0.646 | 0.647 | 0.312 | 0.882 | 1.946 | 0.499 |
| 4 LM does not Granger Cause FII | 5.559 | 0.010 | reject | 0.109 | 0.003 | 7.946 | 0.000 | 9.284 | 0.025 | 24.063 | 0.154 |
| FII does not Granger Cause LM | 4.003 | 0.044 | reject | 2.092 | 0.164 | 2.417 | 0.145 | 3.342 | 0.132 | 1.385 | 0.571 |
| 5 FT does not Granger Cause GROWTH | 0.184 | 0.815 | accept | 0.142 | 0.932 | 0.637 | 0.652 | 0.753 | 0.625 | 2.342 | 0.462 |
| GROWTH does not Granger Cause FT | 0.012 | 0.987 | accept | 0.020 | 0.995 | 0.112 | 0.974 | 0.445 | 0.800 | 11.679 | 0.220 |
| 6 I does not Granger Cause GROWTH | 2.960 | 0.087 | accept | 2.372 | 0.131 | 10.365 | 0.004 | 22.011 | 0.005 | 1.821 | 0.513 |
| GROWTH does not Granger Cause I | 0.032 | 0.968 | accept | 0.072 | 0.973 | 0.505 | 0.734 | 1.031 | 0.502 | 0.615 | 0.750 |
| 7 LM does not Granger Cause GROWTH | 0.022 | 0.977 | accept | 0.084 | 0.966 | 2.065 | 0.189 | 0.921 | 0.546 | 38.092 | 0.123 |
| GROWTH does not Granger Cause LM | 0.002 | 0.997 | accept | 0.012 | 0.997 | 0.005 | 0.999 | 0.077 | 0.992 | 0.502 | 0.790 |
| 8 FT does not Granger Cause FT | 0.689 | 0.519 | accept | 0.383 | 0.767 | 0.568 | 0.694 | 0.399 | 0.829 | 0.940 | 0.657 |
| FT does not Granger Cause I | 1.052 | 0.377 | accept | 0.554 | 0.656 | 0.193 | 0.934 | 0.160 | 0.964 | 8.497 | 0.256 |
| 9 LM does not Granger Cause FT | 0.303 | 0.741 | accept | 0.548 | 0.660 | 0.716 | 0.606 | 0.908 | 0.552 | 1.780 | 0.518 |
| FT does not Granger Cause LM | 1.607 | 0.237 | accept | 1.386 | 0.303 | 1.437 | 0.316 | 6.526 | 0.046 | 7.304 | 0.003 |
| 10 LM does not Granger Cause I | 2.575 | 0.114 | accept | 4.616 | 0.028 | 4.909 | 0.032 | 5.673 | 0.058 | 60.116 | 0.009 |
| I does not Granger Cause LM | 0.147 | 0.866 | accept | 0.870 | 0.488 | 0.791 | 0.866 | 1.360 | 0.343 | 0.962 | 0.652 |

Source: authors' development

Table 9 shows the results of Pairwise Granger Causality Test on cause-effect dependence with 2, 3, 4, 5 and 6 lags, which show the effect of one factor on another in our model.
4 Conclusion

Researched problem proves the significant role of the era of digital globalization, which is characterized by objectivity and irreversibility of the process of formation of information economies, continuous and rapid data flows that contain knowledge and innovations, ideas and information. Positive effects of digitization will soon be manifested through increased efficiency, faster receipt of necessary information and the establishment of mutually beneficial relations with other entities, optimization and scaling of operations, and so on. For Ukraine, this will be manifested through the growth of the activity of TNCs, which will lead to the growth of FDI attraction and to increase the competitiveness of the national economy on the world market to increase investments in innovations.

In this article, the authors analyze the determinants of investment-innovation development of the country’s economy, which are necessary for digital transformation. The constructed model showed a high level of sensitivity of FDI and costs made on innovations from the rate of employment and inflation. Predictions are confirmed that

Table 10. Interpretation of Granger test results

| lag 2                      | lag 3                      | lag 4                      | lag 5                      | lag 6                      |
|---------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| GROWTH there is no connection FII | GROWTH there is no connection FII | GROWTH there is no connection FII | GROWTH there is no connection FII | GROWTH there is no connection FII |
| FT there is no connection FII | FT there is no connection FII | FT there is no connection FII | FT there is no connection FII | FT there is no connection FII |
| I there is no connection FII | I there is no connection FII | I there is no connection FII | I there is no connection FII | I there is no connection FII |
| LM → FII                  | LM → FII                  | LM → FII                  | LM → FII                  | LM → FII                  |
| FT there is no connection GROWTH | FT there is no connection GROWTH | FT there is no connection GROWTH | FT there is no connection GROWTH | FT there is no connection GROWTH |
| I there is no connection GROWTH | I there is no connection GROWTH | I → GROWTH               | I → GROWTH               | I there is no connection GROWTH |
| LM there is no connection GROWTH | LM there is no connection GROWTH | LM there is no connection GROWTH | LM there is no connection GROWTH | LM there is no connection GROWTH |
| I there is no connection FT | I there is no connection FT | I there is no connection FT | I there is no connection FT | I there is no connection FT |
| LM there is no connection FT | LM there is no connection FT | LM there is no connection FT | LM → FT                  | LM → FT                  |
| LM there is no connection I | LM → I                    | LM → I                    | LM → I                    | LM → I                    |

Source: authors’ development

Table 10 shows the interpretation of the Granger test from the point of view of the direction of causal relationships between selected variables studied in the model.
digitization will help to release jobs, increase unemployment and rethink the role of the employee in the society and in the company. The growth of the level of foreign trade by 1% will contribute to the growth of the sum of FDI and investments in innovations, which is a positive trend for information transformation of Ukraine’s economy. GDP in our model does not play a significant role however, we consider that increasing the volume of innovative competitive products will have a positive impact on foreign investors and innovators.

Prospects for the study should focus on the creation and promotion of digital platforms, on the support of innovative companies, on creating an attractive environment for investment and innovation development of the country. At the same time, further steps are studies that will reveal the following important questions: How will Covid-19 affect the economic development of the world and determine the trends of information transformation? What incentives should be given to companies to support them, which invest in innovative, high-tech products? What steps should the country take to accelerate digital transformation reforms?

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