Modeling the Impact of Foreign Investment Flows Taking into Account Time Lags in the Context of their Impact on the Regional Production

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*Abstract***:** *Peculiarities of regional processes of foreign direct investment impact on the gross domestic product of Western Ukraine and Chernivtsi region, taking into account a time lag, are reviewed in this article. Considering the fact that investment processes are enough complicated phenomenon to understand in the course of which different kinds of changes occur, the relevance and importance of establishing a pattern of their behavior is increasing. Economical and mathematical tools, in particular Almon distributed lag models which allow to estimate the discrete lag influence of determinants can be used to achieve this.*

In the course of the study, the Almon distributed lag models were constructed separately for the comparison, time lag interval boundaries were set, the main features of the discrete time lag distribution during the lag period were determined, and the economic and mathematical models of the distributed lag for the effects of foreign direct investment on the gross regional product of Chernivtsi region Western Ukraine were built. On the basis of the obtained results, conclusions about economic multiplier processes of the investment were made in the context of individual territories and the main trends of the investment flow return were defined.

Keywords : *Modeling the impact of foreign investment flows, time lags, Almon lags, regional production.*

I. INTRODUCTION

In the context of current trends of decentralization and focusing on regional development, research of the economic growth of separate territories, taking into account their particularities at the micro and macro levels, is a perspective

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area of the research. This sphere becomes more relevant with the development of the theory of developmentalism, the theory of innovation and innovation development, as well as their comparison with the theory of neoclassical synthesis, since taking into account factors from all the theories makes it possible to investigate the factors of development, defining them at the micro- and mezo-levels of the national economy. The study of the impact of foreign investment flows on the regional production, taking into account time lags, using economic and mathematical tools, gives an opportunity to consider this phenomenon more specifically and evaluate the efficiency of usage and the multiplier effect on the regional development of separate territories. It is also important to distinguish the development of individual territories in the context of the development of certain regions of the national economy. Consideration of this issue takes place in the context examining the regions of Western Ukraine in contrast to the development of Chernivtsi region, gives an opportunity of more practical assessment of the importance of this issue in the context of modern economic realities.

II. PURPOSE OF THE STUDY

To study and analyze the impact of foreign investment on regional economic growth in the context of the separate territory and the comparison with the development of the whole economic region using economic and mathematical tools, in particular Almon distributed lag models [1]. To perform the analysis on the basis of the main correlation and determination coefficients applying correlation and regression analysis, to build a model of the impact of foreign direct investments on the gross regional product, having made appropriate conclusions.

III. ANALYSIS OF THE MAIN STUDIES AND PUBLICATIONS

It is possible to face the investigation of this issue in the writings of both our and foreign economists, as nowadays the theory of innovation and innovative development tends to rethinking in the context of regional development. This topic was researched by foreign economic researchers such as Ronald McQuaid (2015) [2],

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Philip McCann (2017) [3], Daniel Shefer (2013) [4], Nadir Kinossian (2018) [5] and others. Scientific works and publications of these researchers were related to the consideration of the regional development in the context of attraction of foreign and private investments, consideration of regional economic policy and investments as one of the factors of its formation and study of regional development in the countries of Southeast Europe.

Similar topics were discussed in the works of our researchers, in particular by Lidiia Shynkaruk (2017) [6], Valerii Heyets (2016) [7] and Tatiana Artiomova (2017) [8] and other [9]. Their studies were related to structural changes in the economy, regions and the brunch structure of economics in the context of the influence of investment flows.

IV. METHODOLOGICAL FOUNDATION

The tools of economic and mathematical analysis, in particular the Almon distributed lag model, should be used for more detailed analysis. The prerequisite for using this model is the very essence of the definition of the investment. Since this economic resource does not immediately have an effect and may have different influence on the economic system, it is therefore appropriate to take into account the time difference between the investment of the resource and its return, or the so-called time lag. To define the time lag that accompanies a particular phenomenon, a mutually correlative function is used in economic and mathematical modeling which enables to determine the time lag occurring in regression. The general formulation of the correlation function is as follows [1]:

$$r_\tau = \frac{(n-\tau)\sum_{t=1}^{n-\tau} y_t x_{t-\tau} - \sum_{t=1}^{n-\tau} y_t \sum_{t=1}^{n-\tau} x_{t-\tau}}{\sqrt{[(n-\tau)\sum_{t=1}^{n-\tau} y^2 - (\sum_{t=1}^{n-\tau} y_t)^2] - [(n-\tau)\sum_{t=1}^{n-\tau} x^2 - (\sum_{t=1}^{n-\tau} x_t)^2]}} \quad (1)$$

where n – the sample volume; τ — the specific time lag; t – the time period of the consideration of the phenomenon; y_t — the meaning of the dependent variables in the period t; x_t — the meaning of the determinant variables in the period t; r_τ — coefficient of the mutual correlation of time lag.

The mutual correlation function determines the most significant time lags. If the lag has a direct correlation, it will exist in the interval (0; 1), and the intensity of the connection of the time lag will be determined by the movement to the value 1. If the lag has an inverse correlation, it will be in the interval (-1; 0), and the intensity will be determined by the movement of the coefficient up to -1.

V. RESULTS AND DISCUSSION

The development of territories and regions in the context of attracting foreign direct investments is an important component of their effective functioning in the current economic realities of any economy. This problem is of particular relevance for the regions and territories of Ukraine, which are currently in the process of decentralization and, accordingly, are seeking opportunities for their own autonomous development and economic growth. It should be admitted, that the multiplier effect of investments in different regions and territories is implemented differently. In particular, considering this phenomenon in comparison with separate economic regions, it can be admitted that the return on investment and investment attractiveness in the Chernivtsi region differs from Kiev or Odessa regions. Therefore, the study of the behavior of investment processes in the territories and regions is significant in determining the positive and negative factors for their implementation and in the search of prospects for improving their investment attractiveness.

Taking into account the data provided by the State Statistics Service of Ukraine, the data on the dynamics of foreign direct investments and the gross regional product of Chernivtsi region as well as of the whole region of Western Ukraine, including Transcarpathian, Chernivtsi, Ivano-Frankivsk, Lviv, Ternopil, Volyn and Rivne regions were distinguished and consolidated. Comparison of development and comparison of features of investment processes in the context of the separate territory and region gives a more complete and objective understanding, regarding their economic development and possibilities of optimization of these economic processes in the future. Table-I provides information on the gross regional product of Chernivtsi region and Western Ukraine.

Table-I Dynamics of the gross regional product and foreign direct investments of Chernivtsi region and Western Ukraine during 2010-2018

Year	Gross regional product of Chernivtsi region (million UAH)	Foreign direct investments of Chernivtsi region (million USD)	Gross regional product of Western Ukraine (million UAH)	Foreign Direct Investments in Western Ukraine (million USD)
2010	9 892	61,8	130 329	2 846,6
2011	11 969	61,9	162 111	2 661,1
2012	13 166	61,9	188 575	2 947,7
2013	13 757	64,2	192 393	3 151,4
2014	15 049	80,2	224 330	3 413,8
2015	18 506	68,6	281 598	2 995,8
2016	21 239	59,1	326 160	2 736,3
2017	28 591	57,1	424 443	2 488
2018	29 877,6	42,6	442 238,8	2 632,9

Source: Research results – the base for calculations are data from UKRSTAT (2019) [10]

Table-1 shows a high enough volatility of the dynamics of the gross regional product and the volume of foreign direct investments both in Chernivtsi region and in Western Ukraine during 2010-2018. Such dynamics demonstrate the direct impact of the crisis macroeconomic distortions experienced by the Ukrainian economy during this period, which have directly or indirectly affected both the investment attractiveness and the stability of the economic systems of the regions and their economic entities, as well as the macro and meso levels.

Taking into account the data and logical assumptions, the results of the function of the mutual correlation were calculated for the samples of the data stated above for Chernivtsi region and Western Ukraine for time lag values in the interval $\tau = \overline{0; 5}$. The results of the analysis are presented in the Table-II.
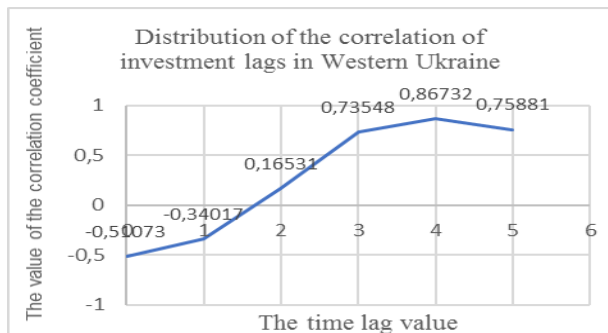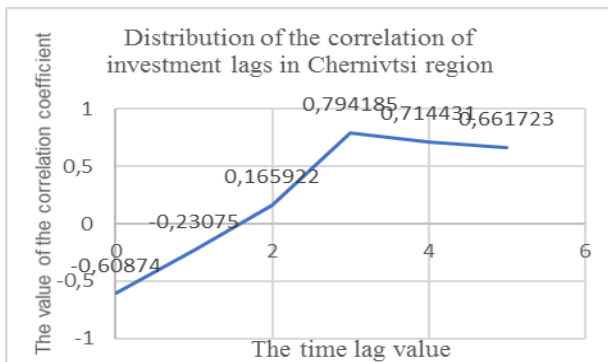
Table-II Value of the mutual correlation function for samples of Chernivtsi region and Western Ukraine for the time lag interval $\tau = \overline{0; 5}$

For Chernivtsi region					
τ	0	1	2	3	4	5
r_τ	-0,60874	-0,23075	+0,165922	+0,794185	+0,714431	+0,661723
For Western Ukraine					
τ	0	1	2	3	4	5
r_τ	-0,51073	-0,34017	+0,16531	+0,73548	+0,86732	+0,75881

Source: Research results – the base for calculations are data from UKRSTAT (2019) [10]

As it can be noticed, the highest correlation of the time lag is observed for the value $\tau = 3$ for Chernivtsi region, and $\tau = 4$ for Western Ukraine. Graphically, the time lag correlation distribution is shown in the Fig. 1.

Analyzing the time lags, it should be admitted that the speed of realization of investments in Chernivtsi region for one year is faster in comparison with the whole Western Ukraine. This phenomenon should be considered on the plane that, comparing the volume of investments in other territories of Western Ukraine, it can be concluded that too little investment flows from abroad are directed to Chernivtsi and its region, and therefore due to the small scale of projects the realization of investments is occurring faster.

Fig. 1. Graphical representation of distribution of the time lag correlation

By setting the objective time lag value, the regression of the Almon distributed lag can be constructed. This economic and mathematical model is aimed at studying the discrete effect of time lag, and gives the opportunity to evaluate the realization of investments in the course of the process.

The Almon distributed lag model has the general appearance of the *n*-th power polynomial. Each value of the estimation of the regression coefficients $b_j, \; j = \overline{1, m}$, can be represented as a polynomial of the *j*-th power [1]:

$$b_0 = c_0 \tag{2}$$
$$b_1 = c_0 + c_1 + \cdots + c_j$$
$$b_2 = c_0 + 2c_1 + 4c_2 + \cdots + 2^j c_j$$
$$b_j = c_0 + \tau c_1 + \tau^2 c_2 + \cdots + \tau^j c_j$$

After making a number of transformations, the polynomial components are replaced with new variables Z_k in the model. The replacement is carried out according to the following algorithm [1]:

$$Z_0 = x_t + x_{t-1} + x_{t-2} + \ldots + x_{t-\tau} = \sum_{j=0}^{\tau} x_{t-\tau} \tag{3}$$
$$Z_1 = x_{t-1} + 2x_{t-2} + 3x_{t-3} + \ldots + \tau x_{t-\tau} = \sum_{j=0}^{\tau} j x_{t-\tau}$$
$$Z_k = x_{t-1} + 2^k x_{t-2} + 3^k x_{t-3} + \ldots + \tau^k x_{t-\tau} = \sum_{j=0}^{\tau} j^k x_{t-\tau}$$

Substituting new variables into the overall expression of the model instead of polynomials, the following view of the time lag distribution model can be received:

$$y_t = a + c_0 Z_0 + c_1 Z_1 + \cdots + c_k Z_k + \varepsilon \tag{4}$$

Considering these manipulations in the context of models of the impact of foreign direct investment on the gross regional product of Chernivtsi region and Western Ukraine, it is worth admitting that in the first case the Almon distributed lag model will be expressed by the third order polynomial and in the second case the second order polynomial. The model construction data are shown in the Table-III.

Table-III Calculations of the Almon model for the sample of Chernivtsi region and Western Ukraine

Model of the distributed lag Almon of Chernivtsi region						Model of the distributed lag Almon of Western Ukraine					
Gross regional product of Chernivtsi region	Direct investments	Z_0	Z_1	Z_2	Z_3	Gross regional product of Chernivtsi region	Direct investments	Z_0	Z_1	Z_2	Z_3
9892	61,8	-	-	-	-	130 329	2 846,6	-	-	-	-
11969	61,9	-	-	-	-	162 111	2 661,1	-	-	-	-
13166	61,9	-	-	-	-	188 575	2 947,7	8 455,3	8 354,3	14 047,5	-
13757	64,2	249,8	371,1	865,7	2225,7	192 393	3 151,4	8 760,2	8 269,9	13 592,1	-

15049	80,2	268,2	373,7	868,9	2230,7	224 330	3 413,8	9 512,9	9 046,8	14 942,2	-
18506	68,6	274,9	394,3	894,1	2265,1	281 598	2 995,8	9 561	9 716,6	16 019,4	-
21239	59,1	272,1	421,6	967,2	2443,6	326 160	2 736,3	9 145,9	9 823,4	16 651	-
28591	57,1	265	436,9	1055,3	2773,3	424 443	2 488	8 220,1	8 727,9	14 719,5	-
29877,6	42,6	227,4	381,1	910,9	2382,1	442 239	2 632,9	7 857,2	7 960,6	13 433,2	-

Source: Research results – the base for calculations are data from UKRSTAT (2019) [10]

Therefore, during the study, the following models of the distributed Almon lag were obtained. The results of constructing the Almon distributed lag model to simulate the impact of foreign direct investments on the gross regional product of Chernivtsi region and Western Ukraine are shown in the Table-IV.

Table-IV The final view of the Almon distributed lag model in the context of the consideration of foreign direct investments for the gross regional product of Chernivtsi region and Western Ukraine

Name	The final formation of the Almon distributed lag model for Chernivtsi region				The final formation of the Almon distributed lag model for Western Ukraine		
The general view of the Almon distributed lag model	$y_t = -312{,}837 - 333{,}253 Z_0 + 1286{,}277 Z_1 - 1055{,}7 Z_2 + 241{,}6235 Z_3$				$y_t = 1176711{,}93 - 314{,}683 Z_0 + 611{,}531 Z_1 - 238{,}419 Z_2$		
The initial view of the Almon distributed lag model	$y_t = -312{,}837 - 333{,}253 x_t + 138{,}9438 x_{t-1} - 50{,}5272 x_{t-2} + 548{,}05 x_{t-3}$				$y_t = 1176711{,}93 - 314{,}683 x_t + 58{,}429 x_{t-1} - 45{,}298 x_{t-2}$		
Relative coefficients of the regression	$\beta_0 = -1{,}099$	$\beta_1 = 0{,}4582$	$\beta_2 = -0{,}167$	$\beta_3 = 1{,}807$	$\beta_0 = 1{,}04355$	$\beta_1 = -0{,}19376$	$\beta_2 = 0{,}15022$

Source: Research results – the base for calculations are data from UKRSTAT (2019) [10]

Considering the regressions of Chernivtsi region and Western Ukraine, it should be noted that they have many differences. First of all, it is a time lag. The length of the time lag in the first regression is 3 years, and in the second it is - 4. Secondly, analyzing the model itself, it should be admitted that in the Chernivtsi region model of the dependence of the gross regional product on foreign direct investments has a negative linear coefficient b. This shows that the state of the regional gross product will be negative before the beginning of investments. Compared to the sample of Western Ukraine, this feature will be negative, since the coefficient b is positive. In addition, it is worth highlighting the return investment features. Both the first and the second regressions will have sinusoidal forms. The highest investment return is observed for the values $x_{t-3} - 548{,}05$ in Chernivtsi region. In addition, they also have a positive investment effect $x_{t-1} - 138{,}94$. As for the values x_t, x_{t-2}, they have a negative effect on the regression -333,253 and -50,5272.

VI. CONCLUSION

The greatest impact on the final result is the investment of the last period. Considering that both negative and positive phenomena are available, it is worth admitting that the greatest impact is made by investments at the initial moment of the lag. Their effect can be estimated at 180.7% of the final result. As for the Western Ukraine, the investments will also be sinusoidal. The positive investment result is observed only in the second year of the time lag with the value x_ (t-1) and the impact is estimated at 58,429 units of the gross regional product growth with the investment growth of this period. In other cases, the negative impact is observed. Speaking about such peculiarities, it is important to point out that the return on investment to Ukraine is a rather volatile phenomenon and depends on the regional policy and the development strategy. Consolidating different regions into the region of Western Ukraine, it is worth admitting that even in such a sufficiently isolated area, there is a considerable economic territorial differentiation by the geographical indication. Therefore, there is a need for a more detailed study of the impact of foreign direct investments on the gross regional product performance of individual territories in the context of the time lag of investment processes.

REFERENCES

1. Almon, S. (1965). The distributed lag between capital appropriations and expenditures. Econometrica, Volume 33, Pages 178-196. Available: https://doi.org/10.2307 / 1911894 [Accessed May 2019]
2. Chen T., McQuaid R., Omar M. (2015). Foreign direct investment industry characteristics and spillovers – a double mechanism model. *Journal of Chinese Economic and Foreign Trade Studies*. Volume 8 (1), Pages 49-66. Available: http://dx.doi.org/10.1108/JCEFTS-02-2015-0006 [Accessed 22 June 2019]
3. McCann, P., & Ortega-Argilés, R. (2017). Regional competitiveness, policy transfer and smart specialization. In R. Huggins & P. Thompson (Eds.), *Handbook of regions and competitiveness: Contemporary theories and perspectives on economic development* (pp. 536–545). Cheltenham, UK: Edward Elgar Publishing. Available: https://doi.org/10.4337/9781783475018.00034 [Accessed 2 July 2019]
4. Shefer, D. and Frenkel, A. (2013). The Center-Periphery Dilemma: Spatial Inequality and Regional Development. In Carmon, N. and Fainstein, S.S. (Eds.). *Policy, Planning, and People: Promoting Justice in Urban Development*. Philadelphia: University of Pennsylvania Press, pp. 183-202. Available: https://doi.org/10.1111/juaf.12185 [Accessed 12 July 2019]

5. Nadir Kinossian. (2018). Planning strategies and practices in non-core regions: a critical response. *European Planning Studies*. Volume 26:2, Pages 365-375. Available: https://doi.org/10.1080/09654313.2017.1361606 [Accessed 23 July 2019]

6. Shynkaruk L., Baranovska I., Milman L. (2017) Key approaches to the doctrine of long-term development of Ukraine. *Bulletin of Taras Shevchenko National University of Kyiv. Economics*. Volume 195. Available: https://doi.org/10.17721/1728-2667.2017.195-6/5 [Accessed 30 July 2019]

7. Heyets, V. M. (2016). Economy of Ukraine: key problems and prospects. *Ekonomika i prognozuvannia*. Volume 1, Pages 7-22. Available: http://nbuv.gov.ua/UJRN/econprog_2016_1_3. [Accessed 3July 2019]

8. Artiomova, T. (2017). European values: traditional concepts in the era of global market transformations. *Economic theory*, Volume 4, Pages 5-31 [In Ukrainian]. Available: https://doi.org/10.15407/eIe12018.03.005 [Accessed 30 July 2019]

9. Halyna Chmeruk, Volodymyr Tokar, Liudmyla Sybyrka, Olena Shaposhnik, Olga Melnyk (2019) Assessing the Level of Enterprise Reengineering in the Context of Global Digitalization. *International Journal of Recent Technology and Engineering (IJRTE)* ISSN: 2277-3878, Volume-8 Issue-4, November 2019, Pages 4103-4109. Available: https://DOI:10.35940/ijrte.D8731.118419 [Accessed 30 December 2019]

10. UKRSTAT. (2019). Available: http://www.ukrstat.gov.ua [Accessed September 2019]

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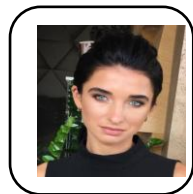
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