GRP Econometric Models for Regions of Ukraine

Maryna Demianchuk
Odessa Mechnikov National University
st. Dvoryanska 2
65026, Odessa, Ukraine
+38-068-334-29-34
ma-demyanchuk@ukr.net

Natalia Maslii
Odessa Mechnikov National University
st. Dvoryanska 2
65026, Odessa, Ukraine
+38-098-883-49-51
masliy.natalia@gmail.com

Valerijs Skribans
Riga Technical University
Kalnciema str. 6,
Riga, Latvia
+371-26429535
valerijs.skribans@rtu.lv

ABSTRACT

Gross Regional Product (GRP) is the most generalized macroeconomic indicator of GDP for a whole state and for regions. In order to understand the peculiarities of the relationship between GRP per person and such indicators as the balance of exports and imports of goods and services of the region, average monthly salary, the volume of educational and medical subventions, it is necessary to analise their volumes in the dynamics of the economic regions of Ukraine, which will allow to see the dependence between the indicators. The purpose of the study is to build econometric models of the dependence of the gross regional product on the main socio-economic indicators of the economic region of the country on the example of Ukraine. Having conducted correlation studies for each economic region of Ukraine, it can be concluded that GRP is influenced by all regressors, i.e. the balance of exports and imports of goods and services, the average monthly salary and the volume of educational and medical subventions are correlated with GRP, which indicates an indirect influence, rather than an individual influence.

CCS Concepts

• Computing methodologies→Modeling and simulation→Model development and analysis→Model verification and validation

Keywords

Gross regional product; econometric models; regional analysis; balance of export and import; average monthly salary; educational and medical subventions; Ukraine.

1. INTRODUCTION

The Ukraine's State Strategy for Regional Development for the period up to 2020 [1] is aimed at identifying objectives and tools for addressing social problems, increasing the economic potential of the territories, the productivity of their economies, the profitability of business and income of the population and, as a consequence, the creation of conditions for the overall improvement of social standards, quality of life and development of the business environment. One of the main objectives of this strategy is to prevent the deepening of regional disparities in the population's access to basic social, public utilities, administrative, transport, information and other services. Changes in the traditional way of life have arisen as a result of increased globalization, urbanization, rural depopulation, and changes in the settlement system and the general openness of the world to the movement of labour force, the financial and economic crisis, limited resources, the growth of global demand for food etc. The importance of the study is related to the objective nature of the increase in the individuality of the economy of each region in the context of the decentralization strategy, and therefore the need to regulate the development of economic sectors of the region as an element of an integrated system. In the era of globalization there have been significant changes in the traditional way of life. At the global level, urbanization processes have accelerated: citizens are moving from rural to urban areas and from one country to another for permanent residence. These changes have a positive impact on the development of large cities and negative impact on rural areas, some regions and economic regions of the country, which in turn causes a number of problems, including socio-demographic and administrative. Therefore, the purpose of the study is to build econometric models of the dependence of the gross regional product on the main socio-economic indicators of the economic region of the country on the example of Ukraine.

The paper consist from 4 parts: empirical study, Ukrainian regions analysis, econometric model development and results estimation.

ICEME 2019, July 15–17, 2019, Beijing, China.

ACM ISBN 978-1-4503-7219-0/19/07…$15.00.
DOI: https://doi.org/10.1145/3345035.3345056

2. LITERATURE REVIEW

Theories and models of regional development can be divided into 4 groups:

1. Neoclassical theories and models: J.H. Borst model [2]; the convergence model R. Solow [3] and T. Swann [4], Mankiw-Romer-Weil [5], Barro-Sala-i-Martin [6]; H.W Siebert's theory [7]; the model of R. E. Hall and C.I. Jones [8].

2. Cumulative: the basic model of G. Myrdal [9]; the concept of "poles of growth" F. Perroux, J.R. Budvil, P. Potier, J.R. Lasuen [10]; the aggregate cause of conditionality and urban agglomeration of H.W. Richardson [11]; model of "diffusion of innovation" T. Hagerstrand, P. Haggett [12]; model "volcano" H. Hirsch [13].

3. New theories: the basic theory of NEG (J.D.Harris "market potential" model [14], "basic multiplier" A. Pred [15], P. Krugman formalized theory by J.D. Harris and A. Pred); model of the NZG (modification of the von Tyuner model by M. Fujita and P. Krugman [16], M. Fujita and T. Mori model [17], M. Fujita, P. Krugman and T. Mori, A. Venableles cyclic motion model [18], Krugman "world history" model, Venables and Puga [19]; the theory of agglomeration: the P. Krugman and P. Romer model

[20], the economy model of two regions R. Fiani [21]; the "core-periphery" model of G. Myrdal and A. Hirschman [22], A. Gilbert and J. Gagler [23]; the theory of random growth (the model of G. Ellison and E. Glaser [24], T. Holmes and J. Stevens [25], empirical model of D. R. Davis and D. E. Weinstein [26]; economic model of spatial lags Lungyan Inna.

4. Other theories: such as model of the location of production by J. Tinbergen and H. Bos [27]; the theory of the export base: the theory of the economic base; the raw material theory; sector theory; theory of flexible specialization; the "cost and output" (input / output) model.

These theories and models have been applied in specific countries, taking into account their economic and social characteristics, which is a prerequisite for the creation of a model for the development of economic regions of Ukraine.

3. UKRAINIAN REGIONS ANALYZE

Ukrainian regional science considers today economic zoning as a means of managing economic structures in the territorial context and as a basis for the development and implementation of state regional policy. Generalization of literary sources on economic zoning allows to consider this economic category from the theoretical point of view at least in three aspects [28]: zoning as a process, comes objectively and does not depend directly on the will of people; zoning as a procedure of delimitation of economic regions; zoning as a "means of spatial regulation of economic and geographic information". Currently, in Ukraine there are usually nine economic regions with their industrial specialization [28].

The main indicators of socio-economic development of economic regions of Ukraine in 2017 are presented in Table 1 and Table 2.

Gross Regional Product (GRP) is the most generalized macroeconomic indicator of GDP for the whole Ukraine and for the regions (Fig. 1). In order to understand the peculiarities of the relationship between GRP per person and such indicators as the balance of exports and imports of goods and services of the region, average monthly salary, the volume of educational and medical subventions, it is necessary to analise their volumes in the dynamics of the economic regions of Ukraine, which will allow to see the dependence between the indicators (Table 3).

According to the presented data, which represent economic indicators, it is possible to construct an economic and mathematical model of dependence of a random value of Y (GRP per person) on random values X1 (balance of export and import of goods and services), X2 (average monthly salary) and X3 (educational and medical subventions).

Having conducted correlation studies for each economic region of Ukraine, it can be concluded that GRP is influenced by all regressors, i.e. the balance of exports and imports of goods and services, the average monthly salary and the volume of educational and medical subventions are correlated with GRP, which indicates an indirect influence, rather than an individual influence. It is also possible to speak about the phenomenon of multicollinearity in the model, because there is also a correlation between variables X1, X2 and X3.

Table 1. Main indicators of social and economic development of the capital, North-Eastern, Pridneprovsky and central economic regions of Ukraine for 2017.

Indicators	Ukrainian economical regions										
	Capital					South-East		Pridneprovskiy		Central	
	Kievskiy	Kiev	Zhitomirskiy	Chernigovskiy	Kharkovskiy	Symskiy	Poltavskiy	Dnepropetrovskiy	Zaporozhskiy	Cherkaskiy	Kirivigradskiy
The number of registered unemployed at the end of the period , thsd.	14	9	14	7	23	15	24	27	22	18	17
The average monthly wage of one employee											
nominal, UAH	7,049	10,870	5,711	5,471	6,135	5,819	6,435	6,820	6,733	5,931	5,702
real,% (2017 / 16)	120	111	127	129	120	124	123	119	117	125	126
Arrears on payment of wages - total, UAH million	144	98	4	4	231	127	33	148	113	116	17
Consumer Price Index (2017 /16)	114	113	113	112	114	114	113	113	114	115	114
Volume of sold industrial products, mln	84,842	154,595	33,476	9,170	149,413	35,102	143,240	372,766	167,786	521,12.8	22,577
Industrial production index (2017 to 2016)	108	95	108	107	106	101	99	100	106	99	104
Agricultural Products Index (2017 to 2016)	94	x	105	105	91	100	83	100	97	88	86
Volume of executed construction works, mil. UAH	5,766	24,826	1,501	1,158	10,031	1,231	5,556	9,171	2,388	1,194	1,433
Construction	122	130	139	100	123	96	117	129	123	100	153

Products Index (2017 to 2016)											
Exports of goods, mln. USA	1,605	8,928	542	128	1,083	599	1,691	6,376	2,836	560	390
Imports of goods, mln. USA	3,109	17,696	419	102	1,472	493	1,048	4,188	1,179	374	205
Balance (+, -)	-1,504	-8,769	122	26	–390	106	643	2,188	1,657	186	185
Cargo turnover, mln tkm	1,744	6,863	4,044	1,106	23,944	7,371	x	26,475	9,441	10,562	26,447
Passenger turnover, mil. pass. km	3,102	26,531	2,211	879	8,285	2,424	2,547	5,296	2,241	26,699	2,413
Retail turnover, mln. UAH	55,090	158,236	20,009	13,593	64,892	16,374	25,784	72,409	36,293	19,631	15,417

Source: formed by authors based on data [29].

Table 2. Main indicators of the socio-economic development of the Podolsk, Carpathian, North-Western and Black Sea economic regions of Ukraine for 2017.

Indicators	Ukrainian economical regions											
	Podolskiy			Carpathian				South-West		Black Sea region		
	Vinnitskiy	Ternopolskiy	Khmelnitskiy	Zakarpatskiy	Lvovskiy	Ivano-Frankovskiy	Chernovtsy region	Volynskiy	Rovenskiy	Nikolaevskiy	Odesskiy	Khersonskiy
The number of registered unemployed at the end of the period , thsd.	20	9	12	5	15	9	11	8	13	18	13	11
The average monthly wage of one employee												
nominal, UAH	5,986	5,437	5,791	6,194	6,256	5,995	5,543	5,719	5,861	6,520	6,383	5,720
real,% (2017 to 2016)	129	151	128	129	124	127	122	126	120	118	117	124
Arrears on payment of wages - total, UAH million	12	9	7	10	87	34	13	34	61	105	50	10
Consumer Price Index (2017 to 2016)	113	113	114	114	113	114	114	115	115	114	115	114
Volume of sold industrial products, mln	60,604	17,163	34,256	18,695	72,856	41,666	24,978	24,208	31,044	45,232	47,877	23,717
Industrial production index (2017 to 2016)	108	108	101	100	106	112	96	105	109	102	112	103
Agricultural Products Index (2017 to 2016)	96	107	110	99	106	103	105	104	104	91	99	99
Volume of executed construction works, mil. UAH	3,029	1,574	2,199	961	5,793	1,910	926	1,474	1,455	2,451	10	970
Construction Products Index (2017 to 2016)	111	103	122	106	104	112	127	98	107	109	138	130
Exports of goods, mln. USA	1,115	343	424	1,325	1,451	594	552	619	351	1,702	1,660	268
Imports of goods, mln. USA	372	324	378	1,232	1,985	563	407	1,239	305	700	1,330	184
Balance (+, -)	743	19	46	93	–533	31	144	–621	46	1,002	330	84
Cargo turnover, mln tkm	27,271	2,108	1,630	7,886	10,973	1,178	886	1,606	10,990	874	65,274	5,373
Passenger turnover, million pass. km	6,744	1,780	1,112	3,101	4,629	1,257	778	2,014	2,704	1,525	11,487	2,026
Retail turnover, mln. UAH	21,097	11,680	20,369	18,316	51,899	19,347	15,777	15,336	14,934	19,523	62,962	19,327

Source: formed by authors based on data [29].

Table 3. Dynamics of welfare indicators of economic regions of Ukraine

Economic areas	GRP per one person (in actual prices), th. UAH				The balance of exports and imports of goods and services, million USD				Average monthly salary, th. UAH				Educational and medical subventions, mil. UAH			
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2014	2015	2016	2017
Capital	27.6	32.1	42.0	51.5	-2,387	-1,184	-411	-1,100	2.8	3.0	3.6	4.4	2,376	2,273	2,338	4,828
Northeastern	31.5	36.8	49.8	60.0	1,558	1,209	931	331	2.9	3.1	3.6	4.4	3,541	3,095	3,126	6,235
Donetsk	62.3	41.9	37.6	46.6	10,056	7,284	2,526	2,627	3.5	3.6	4.2	5.3	1,934	3,957	1,910	3,214
Dnieper	38.4	45.5	58.3	67.6	6,520	6,405	4,988	3,691	3.2	3.5	4.3	5.1	3,519	3,164	3,243	6,033
Central	25.9	29.9	40.1	47.7	866	813	514	429	2.6	2.8	3.3	4.1	1,593	1,355	1,404	2,702
Podolsky	19.8	24.0	31.3	37.9	299	644	851	825	2.6	2.7	3.3	4.0	2,717	2,251	2,332	4,683
Carpathian	20.3	22.9	28.5	32.9	-1,692	-943	488	373	2.6	2.8	3.4	4.2	3,758	3,345	3,465	7,118
Northwestern	19.4	24.0	30.4	34.1	-253	176	228	-409	2.7	2.9	3.4	4.2	1,356	1,331	1,381	2,544
Black sea coast	25.3	27.8	37.8	45.6	1,018	2,335	3,063	2,396	2.8	3.0	3.7	4.6	3,073	2,804	2,913	5,426

Source: formed by authors based on data [29].

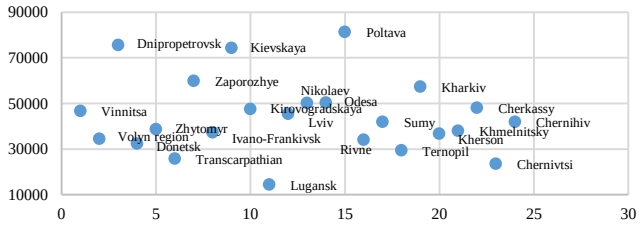

Figure 1. Gross regional product (per person) by regions for 2016

Source: formed by authors based on data [29].

4. ECONOMETRIC MODELS

For each economic region, we will use a multifactor regression model, taking into account the socio-economic status of each region. Econometric models was developed with least squares function approximation.

Thus, for the Capital Region, the model looks as follows:

$$Y = 2.2X_1 + 13.9X_2 - 0.0003X_3 - 6{,}208.9 \quad (1)$$

Equation coefficients show the quantitative impact of each factor on the effective indicator, while others remain unchanged. In our case, GRP per person increases by 2.1804 units with the balance of exports and imports of goods and services increasing by 1 unit, while the other two indicators remain unchanged; GRP per person increases by 13.9181 units, while the average monthly wage increases by 1 unit, while the other two indicators remain unchanged; GRP per person decreases by 0.0003 units, while the educational and medical subventions increase by 1 unit, while the other two indicators remain unchanged.

For the Northeast Region, the multifactor regression model has the following form:

$$Y = 758{,}389.5 - 269.4X_1 - 106.1X_2 - 0.02X_3 \quad (2)$$

Equation coefficients show the quantitative impact of each factor on the effective indicator, while others remain unchanged. In our case, GRP per person decreases by 269.3997 units with the balance of exports and imports of goods and services increasing by 1 unit with two other indicators remaining constant; GRP per person decreases by 106.0447 units with the average monthly wage increasing by 1 unit with two other indicators remaining constant; GRP per person decreases by 0.0228 units with the educational and medical subventions increasing by 1 unit with the other two indicators remaining unchanged.

For the Pridneprovskiy region the multifactor regression model has the following appearance:

$$Y = 33.1X_1 + 80.4X_2 - 0.004X_3 - 437{,}507.0 \quad (3)$$

Equation coefficients show the quantitative impact of each factor on the effective indicator, while others remain unchanged. In our case, GRP per person increases by 33.1004 units with the balance of exports and imports of goods and services increasing by 1 unit with the other two indicators remaining unchanged; GRP per person increases by 80.3524 units with the average monthly wage increasing by 1 unit with the other two indicators remaining unchanged; GRP per person decreases by 0.0042 units with the educational and medical subventions increasing by 1 unit with the other two indicators remaining unchanged.

For the Central Region, the multifactor regression model has the following form:

$$Y = 34{,}378.1 - 24.1X_1 + 5.0X_2 + 0.0014X_3 \quad (4)$$

Equation coefficients show the quantitative impact of each factor on the effective indicator, while others remain unchanged. In our case, GRP per person decreases by 24.0806 units with the balance

of exports and imports of goods and services increasing by 1 unit with the other two indicators remaining unchanged; GRP per person increases by 4.9798 units with the average monthly wage increasing by 1 unit with the other two indicators remaining unchanged; GRP per person increases by 0.0014 units with the educational and medical subventions increasing by 1 unit with the other two indicators remaining unchanged.

For the Podolskiy region, the multifactor regression model has the following form:

$$Y = 8.8X_1 + 10.6X_2 - 0.0003X_3 - 9{,}856.9 \quad (5)$$

Equation coefficients show the quantitative impact of each factor on the effective indicator, while others remain unchanged. In our case, GRP per person increases by 8.8274 units with the balance of exports and imports of goods and services increasing by 1 unit with the other two indicators remaining constant; GRP per person increases by 10.5836 units with the average monthly wage increasing by 1 unit with the other two indicators remaining constant; GRP per person decreases by 0.0003 units with the educational and medical subventions increasing by 1 unit with the other two indicators remaining constant.

For the Carpathian region, the multifactor regression model has the following form:

$$Y = 10{,}535.2 + 1.9X_1 + 4.9X_2 + 0.0001X_3 \quad (6)$$

Equation coefficients show the quantitative impact of each factor on the effective indicator, while others remain unchanged. In our case, GRP per person increases by 1.8661 units with the balance of exports and imports of goods and services increasing by 1 unit with the other two indicators remaining unchanged; GRP per person increases by 4.9143 units with the average monthly wage increasing by 1 unit with the other two indicators remaining unchanged; GRP per person increases by 0.0001 units with the educational and medical subventions increasing by 1 unit with the other two indicators remaining unchanged.

For the North-Western region, the multifactor regression model has the following form:

$$Y = 7.0X_1 + 10.9X_2 - 0.0002X_3 - 8{,}262.9 \quad (7)$$

Equation coefficients show the quantitative impact of each factor on the effective indicator, while others remain unchanged. In our case, GRP per person increases by 6.9863 units, while the balance of exports and imports of goods and services increases by 1 unit, while the other two indicators remain unchanged; GRP per person increases by 10.8561 units, while the average monthly wage increases by 1 unit, while the other two indicators remain unchanged; GRP per person decreases by 0.0002 units, while the educational and medical subventions increase by 1 unit, while the other two indicators remain unchanged.

For the Black Sea region, the multifactor regression model has the following form:

$$Y = 2.3X_1 + 13.3X_2 - 0.001X_3 - 14{,}713.6 \quad (8)$$

Equation coefficients show the quantitative impact of each factor on the effective indicator, while others remain unchanged. In our case, GRP per person increases by 2.2926 units with the balance of exports and imports of goods and services increasing by 1 unit with the other two indicators remaining unchanged; GRP per person increases by 13.2892 units with the average monthly wage increasing by 1 unit with the other two indicators remaining unchanged; GRP per person decreases by 0.0011 units with the educational and medical subventions increasing by 1 unit with the other two indicators remaining unchanged.

5. RESULTS ESTIMATION

To check for autocorrelation residues, we use the Darbin-Watson criterion:

$$DW = \frac{\sum(e_t - e_{t-1})^2}{\sum e_t^2} \quad (9)$$

Without referring to the tables, you can use a rough rule and assume that there is no autocorrelation of residues if $1.5 < DW < 2.5$. For a more reliable output, it is advisable to refer to the tabular values. According to the Darbin-Watson table at m=3, the critical points for the significance level of 0.05 and the number of observations 16 are: $d_1 = 0.86$; $d_2 = 1.73$.

Thus, $1.73 < DW < 2.27$, that is, $(d_1 < DW < 4 - d_2)$, therefore, there are reasons to believe that there is no autocorrelation, which is one of the proofs of the high quality of the economic and mathematical model of GRP dependence per person on such values as the balance of exports and imports of goods and services, average monthly salary and the volume of educational and medical subventions.

6. ACKNOWLEDGMENTS

This study was funded by European Regional Development Fund (ERDF), Measure 1.1.1.5 “Support to international cooperation projects in research and innovation of RTU”. Project No. 1.1.1.5/18/I/008.

7. REFERENCES

[1] Resolution of the Cabinet of Ministers of Ukraine State Regional Development Strategy for the period up to 2020 № 385 (2014, August 6). Retrieved from: https://zakon.rada.gov.ua/laws/show/385-2014-п?lang=en.

[2] Borts, G. H. & Stein J. I. *Economic Crowth in a Free Market.* New York, London, 1964.

[3] Solow R. M. 1956. Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics*, 70, 65–94.

[4] Swan T. W. 1956. Economic growth and capital accumulation. *Economic Record*, 32, 2, P. 334–361.

[5] Mankiw, N.G., Romer, D. & Weil, D.N. 1992. A Contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics*, 107, 407–437.

[6] Barro, R. J. & Sala-i-Martin X. 2004. *Economic Growth.* London, England.

[7] Siebert, H. 1969. Regional Economic Growth Theory and Policy. Scranton.

[8] Hall, R. & Jones, Ch. 1999. Why Do Some Countries Produce So Much More Output per Woker than Others? *Quarterly Journal of Economics*, V, CXIV, 83–116.

[9] Myrdal, G. 1957. Economic Theory and Underdeveloped Regions. London: Duckworth.

[10] Lasu én, J. R. 1969. On growth poles. *Urban Studies,* 6, 137–152.

[11] Richardson, H. W. 1973. *Regional Growth Theory.* London.

[12] Haggett, P. 1965. *Locational Analysis in Human Geography.* London: E. Arnold Ltd.

[13] Giesch, H. 1979. Aspects of Growth Structural Change and Employment – A. Schumpeterian Perspective. *Weltwirtschinafitiches Archiv.* Band 115. Hen. 4.

[14] Harris, G. D. 1954. The market as a factor in the localization ofproduction. *Annals of the Association of American Geographers,* 44.

[15] Pred, A R. 1966. The Spatial Dynamics of U. S. Uxban-Industrial Growth. Cambridge: MIT Prees.

[16] Fujita, M. & Krugman, P. 1995. When is the economy monocentric: von Thunen and Chambertin unified. *Regional Science and Urban Economics*, 254.

[17] Fujita, M. &Mori T. 1996. Structural stability and evolution of urban systems. *Regional Science and Urban Economics*, 27, 4–5.

[18] Venabies, A. 1996. Equilibrium Locations of vertically linked industries. *International Economic Review*, 37, 2, 341–59.

[19] Krugman P. 1991. Increasing returns and economic geography. *Journal of Political Economy,* 99, 483–499.

[20] Romer, P. 1992. Increasing Returns and New Developments in the Theory of Growth. NBER Working paper.

[21] Fiani, R. 1984. Increasing Returns, Non-Traded Inputs and Regional Development. *Economic Journal*, 308–323.

[22] Hirschman, A. 1958. The Strategy of Economic Development, Yale University Press. New Haven.

[23] Gilbert, A., & Gugler, J. 1982. Cities. Poverty and Development: Urbanization inthe third world. Oxford: Oxford University Press.

[24] Ellison, G., & Glaser E. 1997. Geographic Concentration in U. S. Manufacturing Finns: a Dartboard Approach. *Journal of Political Economy*, 105, 889–927.

[25] Holmes, T, & Stevens, J. 2002. Geographic Concentration and Establishment Scale. *Review of Economics and Statistics*, 84, 682–690.

[26] Davis, D. R., & Weinstein, D. E. 2002. Bones, Bombs and Break Points: The Geography of Economic Activity. *American Economic Review,* 92, 1269–1289.

[27] Bos, H. 1970. *Razmeshchenie khozyaystva* [Accommodation facilities]. V.A. Masha Ed.. Moscow: Progress.

[28] Goroda i oblasti Ukrainy [Cities and regions of Ukraine] (nd). Retrieved from http://ukrainian.su/ekonomika/.

[29] State Statistics Service of Ukraine (nd). Retrieved from http://www.ukrstat.gov.ua.