

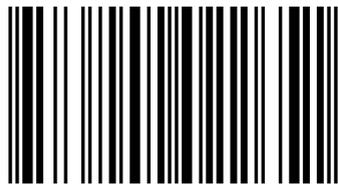
The book investigate the regional unevenness in structure of labor market by mean of evaluation a number of indices, including indices regional structural change in employment, indexes of employment diversification, indexes of dissimilation in the employment structure, regional indexes of economic integration with different groups of countries, geographic attractiveness indices. We proposed a comparative analysis of the dynamic changes in the employment level and sectoral diversification in Ukraine and European Union countries. We estimated the different econometric models that allowed us to assess the impact of the labor market unevenness on the changes in regional employment in general as well as in agricultural and industrial sectors in particular.



Marianna Oliskevych  
Iryna Lukianenko

# Labor Market Modeling: Regional Unevenness and Economic Integration

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978-620-2-02265-1

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Publisher:

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International Book Market Service Ltd., member of OmniScriptum Publishing Group

17 Meldrum Street, Beau Bassin 71504, Mauritius

Printed at: see last page

**ISBN: 978-620-2-02265-1**

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**MODELING OF REGIONAL UNEVENNESS  
AND INTEGRATION PROCESS  
ON LABOR MARKET**

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## **CONTENTS**

<b>INTRODUCTION</b>	5
<b>CHAPTER 1</b> <b>EVALUATION OF UNEVENNESS IN SPATIAL AND SECTORAL EMPLOYMENT STRUCTURE AND THE STRUCTURAL CHANGES ON THE LABOR MARKET</b>	11
1.1 Evaluation of the employment structural changes indices	12
1.2 Comparative analysis of employment structure in Ukraine and in EU countries	14
1.3 Evaluation of sectoral diversification indices of employment in the Ukrainian regions and EU countries	19
1.4 Evaluation of regional employment diversification index for different sectors of economic activity	23
1.5 Evaluation of regional economic integration indices	26
1.6 Evaluation of the geographical attractiveness of the regions	37
<b>CHAPTER 2</b> <b>ECONOMETRIC MODELING OF UKRAINIAN REGIONAL EMPLOYMENT AND ESTIMATION OF INTEGRATION PROCESSES IMPACT</b>	39
2.1 Econometrics models for changes in regional nominal employment, regional employment in agriculture and industry	39
2.2 Econometric modeling of changes in regional employment rate in the context of dynamic changes in the processes of economic integration	45
2.3 Econometric modeling of regional differences in labor productivity	51
<b>CONCLUSIONS</b>	55
<b>REFERENCES</b>	58



## INTRODUCTION

The spatial structure of each country are inherited the different forms of development asymmetry. Inconsistencies in the implementation of economic interests are due from many external and internal factors, including the fact of adapting the institutions to change in economic conditions and disturbance of market environment. Regional disparities cause the deepening inequality in social structure of the national economy; violate the uniformity of the national economy; prevent the effective integration of Ukrainian labor market and convergence.

Analysis of disparities and asymmetric regional development is the subject of many Ukrainian research scientists. An important contribution in the study of regional disparities in Ukraine made [T. Klebanova, L Guryanova, T. Trunova and A. Smyrnova \(2009\)](#), who proposed the author's estimation algorithm and analysis uneven regional development and implemented it for the regions of Ukraine. [O. Rayevneva and O. Bobkova \(2012\)](#) examined the regional unevenness in Ukraine by Theil index decomposition; [V. Oglih and T. Efanova \(2014\)](#) estimated the economic system asymmetry at the level of individual regions. [L. Simkiv \(2013\)](#) studied the asymmetry of Ukrainian regional development and suggested ways of its overcoming.

In Ukrainian scientific literature many works are dedicated to problems of regional unevenness. In particular, [T. Klebanova, T. Trunova and A. Smirmova \(2011\)](#) proposed their author algorithm for evaluation and analysis of regional development unevenness and implemented it for the Ukrainian regions. A number of Ukrainian scientists use mathematical and econometric methods of modeling in their works for studying regional convergence processes and differentiation of spatial patterns. Ukrainian scientists also indicate that unevenness and disparities in socio-economic development of Ukrainian regions is one of the obstacles to the deepening of integration processes ([G. Ortina, 2014](#)).

Many works devoted to the distribution regions of Ukraine into clusters. Scientists offer different schemes of analysis of spatial clustering of socio-economic development rates on the basis of cluster analysis. The theoretical clustering basis is

described by I. Markovskyy (2011); T. Pushkar and V. Fedorova (2011) analyzed the formation of clusters in the world. The presence of heterogeneity in the development of regional labor markets certified O. Nikiforova and L. Chagovets (2011), which shared regions of Ukraine into two clusters using the method of K-means. M. Kyzym and T. Moschitskaya (2011) analyze the presence of inter-regional imbalances and conduct a spatial clustering of Ukrainian regions in 2000, 2005 and 2008 based on three economic indicators: gross regional product per capita, budget income per capita and wages. T. Klebanova, T. Trunova and A. Smirnova (2011) define the algorithm of regions clustering in terms of socio-economic development.

Many Ukrainian scientists to study regional differentiation processes and spatial structures used mathematical and econometric modeling. In particular, L. Chagovets (2011) proposed space-dynamic differentiation model of social-economic regional development; Ya. Prytula and V. Kuzenko (2013) calculated the Theil index and structural changes in the regions of Ukraine and built an econometric model of regional convergence that includes three structural reforms, WTO accession, exchange rate policy and inflation. L. Guryanova, G. Kholodnyi, A. Lukyanchikova (2013) used the Baumol model, spatial lag model and model of conditional convergence with spatial error. A. Yastrebova, O. Nikifirova, L. Chagovetz (2012) proposed a model for equalizing regional differences with the help of tax levers. L. Guryanova, T. Klebanova, O. Sergienko and G. Goncharenko (2012) calculate the  $\sigma$ -convergence ratio based on coefficients of variation and the Gini coefficient for main indicators of socio-economic development of Ukrainian regions for 2000–2009.

In contemporary economic world an important role is paid to the concept of country integration into the global economy, as this economic phenomenon covers various spheres of society activities. Globalization of the world economy, which is caused by increased international cooperation, scientific and technological achievements, changes in the nature of human labor takes place rather quickly and intense. Due to intensified integration processes in Europe scientists detect an increasing correlation between stock markets of Eastern European countries and the Euro-zone (C. Savva and N. Aslanidis, 2010); they note the impact of financial

integration both on the financial and private sectors, sustainable economic environment and economic growth of the European Union countries (A. Adina, 2013); describe the positive effects of European integration on changes in capital and credit markets (Y. Muradoglu, C. Onay, K. Phylaktis, 2014), indicate that high correlation between capital markets of the EU has a significant impact on the work effectiveness of each market as well as on asset and index pricing (P. Alexakis, A. Vasila, 2013).

Foreign scientists M. Gangl (2002), A. Niebuhr and S. Stiller (2006), S. Obradovic (2008) investigate problems of integration and regional unevenness and their works show that each country differently adapts to the integration processes in economic activity. In particular, D. Buccella (2011) conducted a review of theoretical and empirical results which estimate the impact of economic integration and internationalization on the European labor market. D. Kallioras and G. Petrakos (2010) by using econometric models examined the impact of economic integration on the growth of industrial employment in the new member states of the European Union and the relationship between their structural characteristics and geographical attractiveness of the regions.

The country integration into the global economy is an economic phenomenon covering different spheres of society and occupies an important place in economic world. Globalization of the world economy causes the increase of international cooperation, scientific and technological advances, and change the nature of human labor.

A number of Ukrainian scientists study problems of Ukrainian economy integration into the global economy in general and into the EU in particular. Among others O. Zhuravliov (2013) examines the transformation processes in Ukraine in the context of globalized economy, G. Ortina (2014) describes the impact of integration relations on forming the real economy development strategy. I. Sytnik (2011) determined the factors of Ukraine's ability to integrate development on the basis of correlation-regression analysis.

National researchers mention that unevenness and imbalances in socio-economic development of the country's regions are obstacles to achieving a high degree of

Ukrainian integration. Regional development asymmetry gives a rise to emerging of poor and rich regions, which in turn violates the balance of national economy development. Scientists confirm the presence of inter-regional inequality and emphasize structural reforms to increase economic development of Ukraine in the future. They say that eliminating depression and establish the stable homogeneous regions are a priority policy for integration (O. Shevchenko, 2011). B. Yazlyuk (2013) among others describes strategies of modernization and innovation increase of socio-economic security in order to overcome regional asymmetry. M. Pashkevych and Y. Papizh (2014) conduct a study of a problem of regions convergence in transition countries and suggested a systematic approach to regions alignment by number of features. Ya. Prytula and N. Kuzenko (2013) conduct an estimation of regional disproportions in Ukraine based on an econometric model that includes three structural reforms: WTO accession, exchange rate policy and inflation. A. Tischenko (2010) substantiates the requirement for regional strategies development as a pledge of sustainable economic development of the country.

Scientists confirm the existence of interregional disparity and emphasize the need for implementation of structural reforms in order to provide Ukraine's economic growth in the future. Ukrainian scientists also claim that depression eliminating and making all regions stably prosperous is the primary task of the state policy concerning territorial regions.

Research of uneven regional development and integration problems is important in the world scientific literature. S. Obradović (2008), L. Caceres (2014), S. Barrios and E. Strobl (2009), L. Sawers (2006), C. Savva and C. Aslanidis (2010), showed that each country adapt the integration processes in economic activity in different ways. L. Andrei (2014) focused on economic convergence and analyzed the current research integration within the European Union. G. Petrakos and L. Topaloglou (2008) analyzed the impact of integration dynamics on the development of external border regions of the EU. X. Huang, R. Leon-Gonzalez and S. Yupho (2013) applied the cointegration dynamic model to study regional financial integration. I. Maes and L. Quaglia (2003)

substantiate the benefits of European integration in the field of monetary policy. [C. Christiansen \(2014\)](#) investigated integration on the markets of government bonds.

[P. Artelaris, D. Kallioras, G. Petrakos \(2010\)](#) on the basis of nonlinear econometric models examine the evolution of regional disparities in each of the countries - new European Union members and shown the existence of regional convergence clubs. [S. Barrios, E. Strobl \(2009\)](#) carry out an econometric analysis of relationship between inequalities in different regions of the country and its GDP value per capita on the basis of semi-parametric techniques of estimation regional data for several European countries.

Study of economic integration and uneven development in the labor market is of particular importance nowadays. [B. Batavia and P. Nandakumar \(2002\)](#) examines the impact of economic integration on the basis of trade unions standard utility-maximizing model and determines the impact of labor market developments abroad on the domestic wages. [D. Kallioras and G. Petrakos \(2010\)](#) examined the impact of economic integration on the growth of industrial employment in the EU new member states of the European Union by analyzing assessment results econometric models and built the relationship between their structural characteristics and attractive geographic regions. [H. Johansson \(2001\)](#) found that regional integration contributes to productivity growth in the European Union. [K. Bartz, N. Fuchs-Schundeln \(2012\)](#) consider the role of borders, linguistic peculiarities and different currencies in various countries as factors of slowing down the integration processes. Authors on the basis of a modified spatiotemporal autoregressive (STAR) model analyze barriers to integration on the labor market in the European Union and showed that language barriers still play a significant role in deepening the integration processes despite the possibility of free movement across the border and implementation of the single currency. [D. Wildasin \(2000\)](#) emphasizes that investments in human capital increase specialization and skilled workers migration that leads to improvement of labor market efficiency and decentralized public investment in human capital is inefficient and creates unevenness on the labor market. [M. Beenstock and D. Felsenstein \(2008\)](#) note, that socio-

demographic structure of employment across regions must be taken into account for regional convergence analysis.

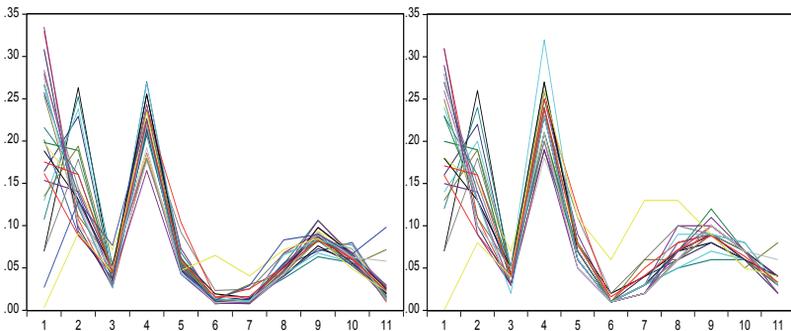
The intensification of economic integration processes taking place in the global economy in general and in Ukraine in particular requires a deepening of scientific researches of their impact on effective functioning of national economy and resolving the existing in Ukraine problem of development imbalances in separate regions. Overcoming disparities in regional development and rise in the competitiveness of domestic labor market will allow increasing rates of economic growth and labor productivity.

At the current stage of globalization and European integration direction of the national economy are important the identification and modeling of economic integration of the regional labor markets in Ukraine. Despite considerable progress in research of economic instability in Ukraine are not sufficiently developed econometric methods for analysis and modeling of regional spatial non-uniformity, and its relationship with the processes of economic integration.

## CHAPTER 1

### EVALUATION OF UNEVENNESS IN SPATIAL AND SECTORAL EMPLOYMENT STRUCTURE AND THE STRUCTURAL CHANGES ON THE LABOR MARKET

The identifying of unevenness factors in the spatial structure of labor markets in the regions of Ukraine needs assessments of the characteristics and spatial distribution of employment. The differences in the spatial distribution of employment can be one of the factors contributing to the differentiation of regional productivity growth over the last decades. Regional production structure of the regions in terms of employment can be described by comparing the proportion of the employed population in each region according to different economic activities, which include: 1) agriculture, forestry and fishery; 2) industry; 3) construction; 4) trade; hotels and restaurants; 5) transport and communications; 6) financial activities; 7) real estate, renting and business activities; 8) public administration; 9) education; 10) health care and social assistance; 11) other economic activities. Figure 1 shows the share of employment in different sectors for 27 regions of Ukraine in 2013 and 25 regions (excluding the Crimea) in 2016.



**Figure 1.** The share of employment of different sectors in the regions of Ukraine

**Source:** data of the State Statistics Service of Ukraine, evaluation of authors.

Statistical data shows that the economic structure of employment in various fields differ for the share of employment in agriculture and industry, while the shares of other sectors for various regions are about the same.

### 1.1. Evaluation of the employment structural changes indices

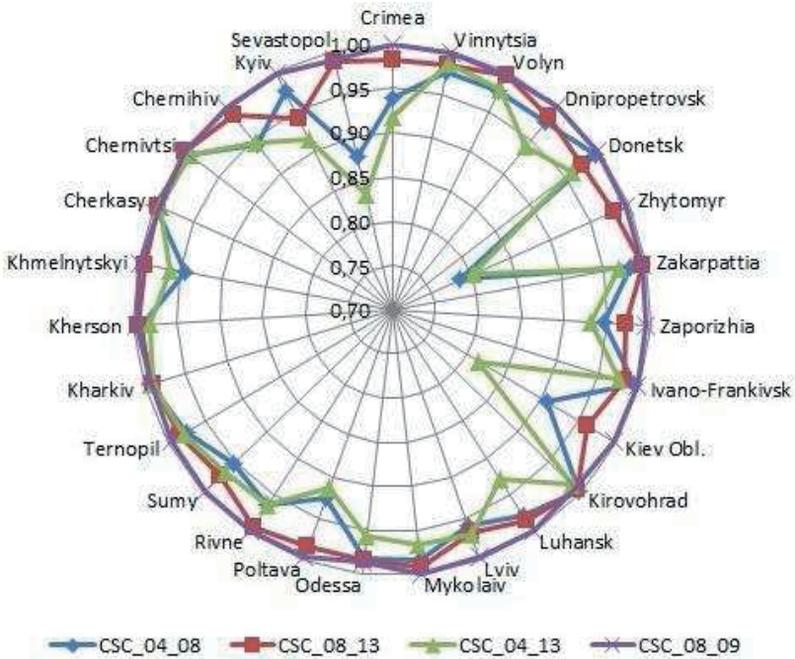
To determine the level of structural changes in employment that took place in different regions of Ukraine it is necessary to estimate the ratio of regional structural changes in employment *RSC* (D. Kallioras, G. Petrakos 2010). *RSC* index is defined as correlation coefficient between the level of employment in various economic sectors ( $i=1, \dots, 11$ ) in each region ( $r=1, \dots, 27$ ) for two different years ( $t_1, t_2$ ) and is calculated by the formula

$$RSC_{i,t_1,t_2} = \text{Corr} [EMPL_{ri}(t_1), EMPL_{ri}(t_2)], \quad (1)$$

where  $EMPL_{ri}(t)$  – number of employees in  $r$ -region in  $i$ -sector of economy for year  $t$ . *RSC* index takes values in the interval  $[0,1]$ , with values close to 0 indicate that during the period  $(t_1,t_2)$  significant structural changes in regional employment took place, while values close to 1 indicate the absence of any change. Calculated values of the *RSC* index for different regions of Ukraine and different time periods are shown in Figure 2.

By analyzing calculated values of the coefficient *RSC* it becomes obvious that different regions demonstrate different responses to changes in economic environment and show different levels of structural adjustment. During the period from 2004 to 2015 six out of 27 regions of Ukraine experienced significant structural changes in employment level (Zhytomyr, Kyiv and Poltava regions, the Autonomous Republic of Crimea, and the cities of Kyiv and Sevastopol) and 7 other regions demonstrate insignificant structural changes, while in all the rest (about half) regions of Ukraine distribution of employment has not changed. It should be noted that most of the

structural changes that have occurred during the pre-crisis period was recorded from 2004 to 2008, while since 2008 to 2015 only a quarter of regions show some insignificant changes in the employment structure (Figure 2) and only Kyiv region can be characterized with constant continuous growth of RSC index during the whole period from 2004 to 2015. For 2013–2016, the calculated RSC indices for all regions of Ukraine exceeds the value 0.99, which reveals that in the period from 2014 to 2016, the regional structure of employment has not changed in comparison with the previous years.

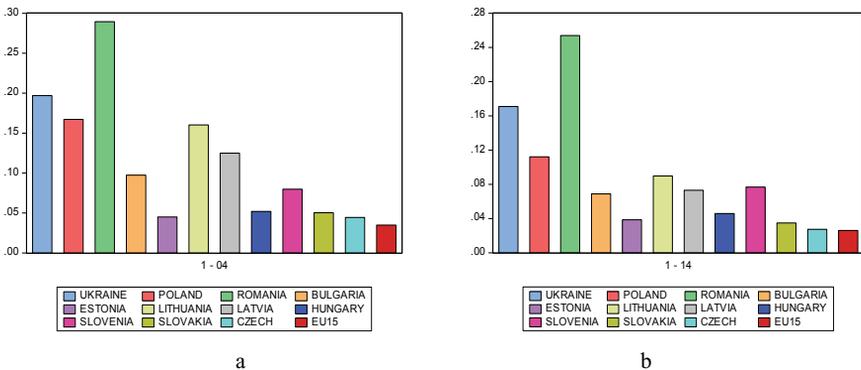


**Figure 2.** Values of structural changes indexes in different regions of Ukraine

**Source:** evaluations of the author.

## 1.2. Comparative analysis of employment structure in Ukraine and in EU countries

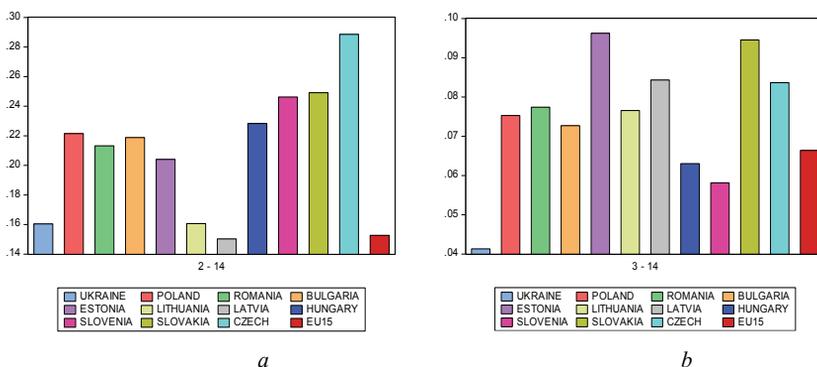
Comparative analysis of percentage of people employed in different economic activities detects considerable differences in the structure of employment distribution according to economic sectors in Ukraine and the EU countries (Figures 3–5). In Ukraine the percentage of employed in agriculture (17.5%) is much higher than the average European level (4.5%) as well as the percentage of employed in sphere of trade (Figures 3, 5a). Should be noted that in some countries that gained EU membership in 2004 – 2007, particularly in the Baltic countries, Bulgaria and Poland in 2004 on the eve of joining the European community percentage of employed in agriculture exceeded the 16%, but as a result of European integration processes this percentage gradually decreased and in 2015 the situation was almost leveled. Thereafter only Romania remains as an agricultural country (25.7%) and Poland slightly exceeds European average level (11.7%). However all countries demonstrate gradual decrease in the percentage of employed in agriculture, indicating an increased labor productivity and improvement of technologies in this economic sector while the percentage of employed in agriculture in Ukraine over the past ten years almost has not being changing.



**Figure 3.** The share of employment in agriculture, hunting, forestry and fishing; a) in 2004; b) in 2015

**Source:** data from EUROSTAT Database, elaborations of the author.

However, in Ukraine the share of employed in industry is significantly lower compared to the EU new member states (Figure 4a). In particular, if in Ukraine the share of employment in industry is approximately 16% then in the Czech Republic, Slovakia, Slovenia, Romania, Bulgaria, Estonia, Hungary and Poland this percentage varies from 22 to 28%. Ukrainian sectors such as construction, transport and financial activities are not enough developed in comparison with Europe (Figures 4b, 5b, 5c), the share of employment in these sectors is almost twice less than in most European countries.

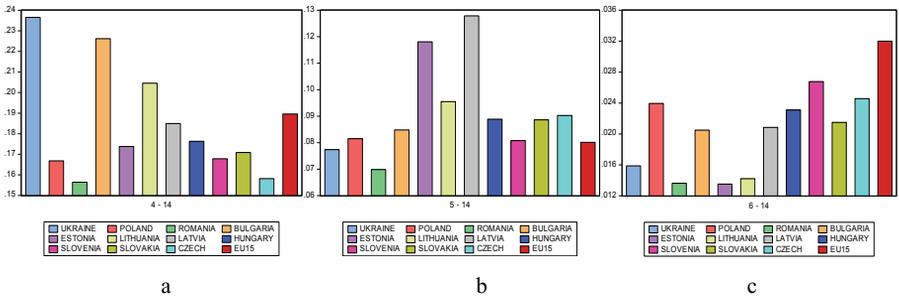


**Figure 4.** The share of employment in a) industry; b) construction in 2015

**Source:** data from EUROSTAT Database, elaborations of the author.

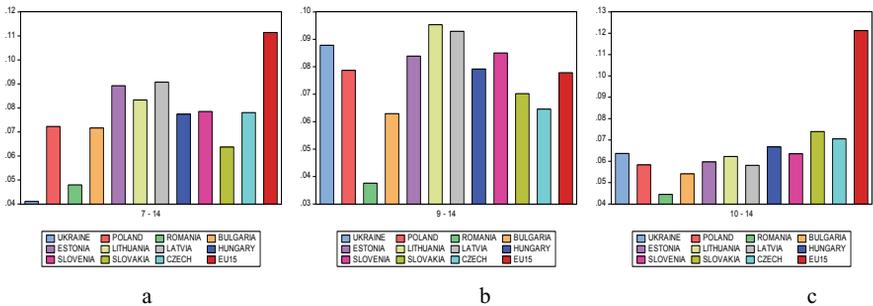
Also the share of employment in the real estate sector is four times lower than in Poland and almost five times lower than the average in the European Union (Figure 6a). Should be noted that in the countries - new EU members before joining the European Union share of this sector was even lower than the Ukrainian level. However, due to the integration processes their share leveled with European rate and is now about 10%, while in Ukraine during the same period this percentage even dropped from 4% to 1.6%. In the sphere of education Ukraine shows European average employment rates Figure 6b, but in health care this proportion (6.2%) is in an equal share with new EU

members [Figure 6c](#), but less than half the proportion of people employed in medicine (12%) in developed countries EU15.



**Figure 5.** The share of employment in a) wholesale and retail trade, repair of motor vehicles and motorcycles, accommodation and food service activities; b) transportation and communication; c) financial activities in 2015

**Source:** data from EUROSTAT Database, elaborations of the author.



**Figure 6.** The share of employment in a) real estate, renting and business activities; b) education; c) human health and social work activities in 2015

**Source:** data from EUROSTAT Database, elaborations of the author.

Comparison of features of structural changes that occur in Ukrainian regions and European countries can be done by dissimilation the employment structure index (*IDES*) (D. Kallioras, G. Petrakos, 2010). *IDES* index evaluates differences in the

distribution of employment between economic  $i$ -sectors for economics of two countries ( $a, b$ ) in a given  $t$ -year and is defined by the formula

$$IDES_{ab} = \sum_{i=1}^n (a_i - b_i)^2. \quad (2)$$

where  $a_i$  i  $b_i$  – employment shares in  $i$ -th economic sector of countries  $a$  and  $b$  respectively.

**Table 1**

***IDES* indexes between Ukraine and European countries**

Year	EU15	Poland	Czech	Slova kia	Slove nia	Hun gary	Lat via	Lithua nia	Esto nia	Roma nia	Bulga ria
2000	3,80	0,34	3,68	2,78	3,04	2,72	0,84	0,34	3,10	3,69	1,25
2001	3,46	0,27	3,78	2,85	3,06	2,60	0,70	0,31	2,79	3,83	1,88
2002	3,46	0,21	3,86	3,02	3,32	2,66	0,50	0,23	2,44	2,60	1,71
2003	3,40	0,29	3,95	3,17	3,26	2,78	0,78	0,20	2,64	3,00	1,68
2004	3,31	0,42	3,76	3,53	2,72	2,64	1,02	0,33	3,21	2,19	1,65
2005	3,27	0,47	3,94	3,55	3,13	2,62	1,05	0,57	2,86	2,12	2,04
2006	2,79	0,59	3,80	3,17	2,43	2,18	0,96	0,49	2,39	2,22	1,77
2007	2,57	0,66	3,84	3,18	2,32	2,03	1,29	0,82	2,55	2,14	1,79
2008	2,47	0,76	3,76	3,14	2,17	1,89	1,62	1,10	2,60	2,14	1,69
2009	2,50	0,89	3,49	2,91	2,03	1,89	1,17	0,81	2,37	2,37	1,69
2010	2,48	0,88	3,63	2,95	2,04	1,94	1,14	0,76	2,30	2,66	1,47
2011	2,94	1,15	4,39	3,74	2,34	2,29	1,37	1,07	3,01	2,06	1,62
2012	3,10	1,24	4,56	4,01	2,39	2,35	1,67	1,12	3,15	2,10	1,91
2013	3,84	1,47	4,66	3,63	2,43	2,65	1,87	1,35	3,17	1,97	1,83
2014	3,33	1,44	4,73	3,51	2,32	2,70	1,95	1,15	3,07	2,07	1,68

**Source:** evaluations of the author.

High values of the index indicate a greater discrepancy while low values indicate minor discrepancies between the structures of economies that are under comparison. Growth of *IDES* values over the time shows that the analyzed economies become more

dissimilar, and decrease of values shows that respective countries become increasingly similar in terms of employment distribution by certain economic sectors. The calculated values of dissimilation index between Ukraine and various countries of European Union are given in Table 1.

Analyzing the calculated values of the *IDES* coefficients it becomes obvious that the employment structure in different economic sectors in Ukraine is the most similar with employment structure in Poland, Lithuania and Latvia and is the most distinctive from the Czech Republic, Slovakia, EU15 countries. However, the dynamics of this index values indicates a deepening of differences with all the countries over the past 10 years (Figure 7).

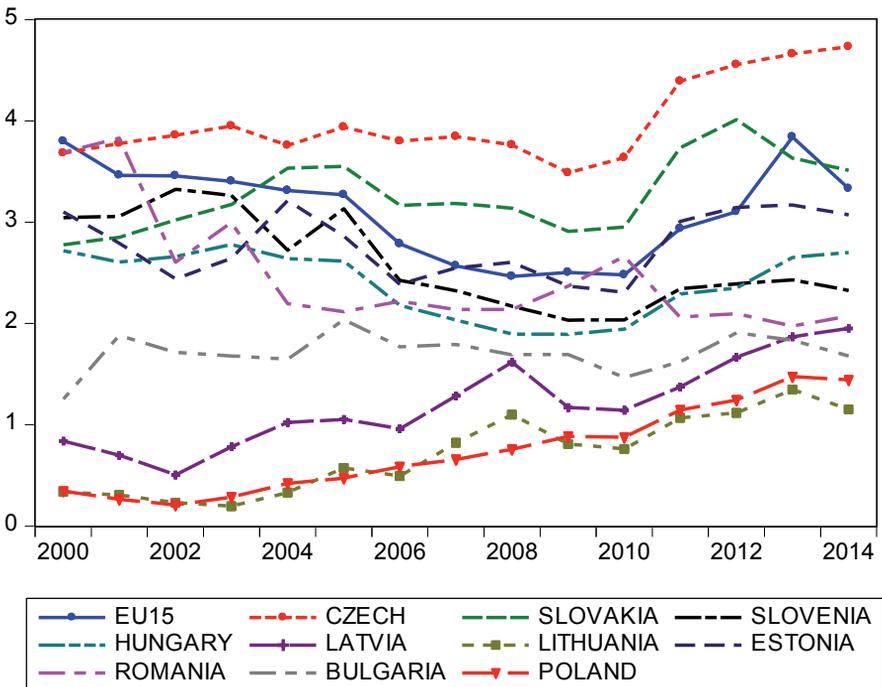


Figure 7. The *IDES* coefficients between Ukraine and European countries

Source: evaluations of the author.

These changes are especially notable in comparison with those countries with which the Ukrainian economy in 2004 was the most similar. In particular coefficient of discrepancies with Poland quintupled (from 0.3 to 1.5).

### 1.3. Evaluation of sectoral diversification indices of employment in the Ukrainian regions and EU countries

To measure the diversification of employment in different labor market sectors in regions of Ukraine we use the Theil index that characterizes the entropy measure of regional disparities in terms of employment sectors and is given by [G. Petrakos, L. Topaloglou, 2008]

$$T_r = \sum_{i=1}^m \frac{e_{ri}}{e_r} \ln \frac{e_r}{e_{ri}}, \quad (3)$$

where  $e_{ri} = \frac{EMPL_{ri}}{\sum_r \sum_i EMPL_{ri}}$  – the share of employment in the  $i$ -th sector of  $r$ -th region;

$e_r = \sum_i e_{ri}$  – the overall proportion of employment in the  $r$ -th region. Note that

$$\frac{e_{ri}}{e_r} = \left( \frac{EMPL_{ri}}{\sum_r \sum_i EMPL_{ri}} \right) / \left( \frac{\sum_i EMPL_{ri}}{\sum_r \sum_i EMPL_{ri}} \right) = \frac{EMPL_{ri}}{\sum_i EMPL_{ri}}$$

– the share of  $i$ -th sector in  $r$ -th region,  $\sum_r \sum_i e_{ri} = 1$ . Due to the division of  $T_r$  to the theoretical maximum  $\ln(m)$ , where  $m$  – the number of sectors, we get the normalized index of sectoral diversification in each region, which includes the value in the interval  $[0, 1]$ . In particular, the normalized index for the region  $r$  takes the value 0 if only one sector exist in this region and 1 if all  $m$  sectors conclude the same number of people. At the national level using the average Theil index

$$\bar{T}_r = \sum_{r=1}^n e_r \ln \frac{1}{e_r},$$

where  $n$  – the number of regions. The value of the sectoral diversification index of employment for different regions of Ukraine in different years is given in Table 2.

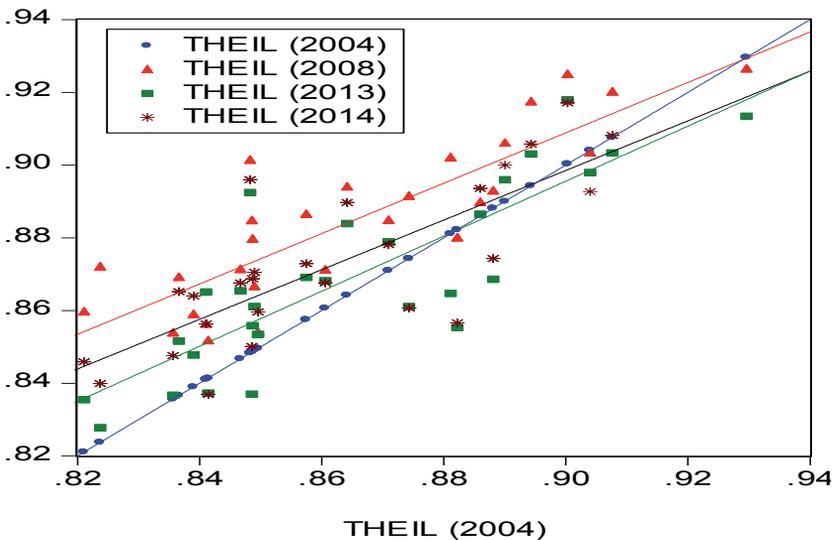
Table 2

**Sectoral Diversification Indexes of Employment in Different Regions of Ukraine**

Region	2004	2008	2009	2013	2014
Crimea	0,8811	0,9020	0,8944	0,8647	—
Vynnytsia	0,8237	0,8720	0,8640	0,8278	0,8399
Volyn	0,8366	0,8691	0,8575	0,8516	0,8652
Dnipropetrovsk	0,8496	0,8540	0,8606	0,8534	0,8596
Donetsk	0,8411	0,8563	0,8609	0,8651	0,8563
Zhytomyr	0,8483	0,9013	0,8946	0,8924	0,8960
Zakarpattia	0,8710	0,8848	0,8929	0,8789	0,8781
Zaporizhia	0,8490	0,8666	0,8757	0,8611	0,8705
Ivano-Frankivsk	0,8743	0,8914	0,8882	0,8611	0,8607
Kiev Obl.	0,9003	0,9249	0,9254	0,9179	0,9171
Kirovohrad	0,8390	0,8589	0,8732	0,8478	0,8640
Luhansk	0,8414	0,8517	0,8539	0,8373	0,8369
Lviv	0,9076	0,9201	0,9193	0,9033	0,9081
Mykolaiv	0,8822	0,8800	0,8692	0,8553	0,8566
Odessa	0,8943	0,9174	0,9121	0,9030	0,9058
Poltava	0,8575	0,8864	0,8827	0,8691	0,8729
Rivne	0,8881	0,8929	0,8883	0,8686	0,8743
Sumy	0,8642	0,8940	0,8984	0,8839	0,8897
Terнопil	0,8486	0,8847	0,8798	0,8370	0,8501
Kharkiv	0,8860	0,8897	0,8871	0,8865	0,8936
Kherson	0,8357	0,8538	0,8546	0,8367	0,8476
Cherkasy	0,8467	0,8713	0,8750	0,8654	0,8676
Chernivtsi	0,8606	0,8711	0,8683	0,8682	0,8676
Chernihiv	0,8487	0,8796	0,8705	0,8558	0,8687
Kyiv	0,9040	0,9033	0,8987	0,8979	0,8927
Sevastopol	0,9296	0,9264	0,9244	0,9134	—

**Source:** evaluation of authors.

The calculated value of regional Theil index show that different regions of Ukraine have different degrees of specialization in sectors which also shows different trends over time. In particular, in 2004 the index of sectors diversification for different regions ranged from 0.821 to 0.907 (with an average of 0.859); in 2008 it increased and was in the range of 0.852 to 0.925 (with a mean value of 0.880), whereas in 2014 it slightly decreased again and was in the range from 0.836 to 0.918 (mean value of 0.872). Note that in most regions (18 regions) over time throughout the period from 2004 to 2014 industrial diversification increased. Moreover, comparing the degree of specialization sectors in regions we see that during this time period there was some alignment of regions in terms of employment in different sectors, as evidenced by decreasing the slope coefficient regression (Figure 8). In particular for the regions with higher in 2004 than the average in Ukraine Theil the index it decreased slightly, while those regions with were characterized at the beginning rather low index Theil and higher degree of sectoral specialization, on the contrary we observe the increase its relative diversification.



**Figure 8.** Change in sector diversification indices

**Source:** evaluation of authors.

Khmelnysky, Chernivtsi, Kherson, Volyn, Kirovograd, Ternopil regions (dominated by agriculture sector, which employs about a third of employees (28-33%)) and Luhansk region (36% of employment in trade, the largest share of the trade sector in Ukraine) are the most specialized among the regions of Ukraine. For the entire period the most diversified by sector regions are Kiev, Lviv, Odessa and Kharkiv regions. Note also that the Zhytomyr region, which in 2004 showed the average index of diversification by reducing the share of employment in agriculture from 28% to 15% now is the most diversified region.

The main difference between Ukrainian economy compared to countries of the European Union is a significant excess shares in agriculture and trading, but shares of construction, industry, transport, finance, real estate sector and healthcare are low. Comparing the level of specialization in employment in Ukraine and other European countries (Table 3) we see that the national economy is somewhat lower degree of diversification.

Table 3

**Sectoral Diversification Index of Employment in Ukraine and Europe**

Year	Ukraine	EU15	Чехія	Slovenia	Hungary	Latvia	Lithuania	Estonia	Bulgaria	Romania	Poland
2000	0,881	0,927	0,885	0,873	0,906	0,915	0,894	0,901	0,880	0,752	0,902
2004	0,890	0,929	0,884	0,888	0,915	0,929	0,904	0,899	0,882	0,816	0,903
2007	0,903	0,930	0,881	0,899	0,913	0,933	0,921	0,915	0,884	0,838	0,912
2008	0,906	0,935	0,888	0,906	0,920	0,935	0,923	0,909	0,892	0,853	0,918
2009	0,905	0,937	0,898	0,918	0,927	0,947	0,934	0,923	0,897	0,858	0,926
2010	0,905	0,937	0,900	0,917	0,927	0,944	0,934	0,923	0,897	0,859	0,929
2011	0,902	0,937	0,894	0,924	0,925	0,947	0,932	0,923	0,899	0,866	0,929
2012	0,900	0,936	0,897	0,931	0,931	0,954	0,933	0,927	0,898	0,861	0,931
2013	0,896	0,935	0,900	0,927	0,931	0,949	0,935	0,929	0,905	0,863	0,931
2014	0,898	0,944	0,897	0,927	0,928	0,948	0,936	0,926	0,911	0,869	0,933

Source: evaluation of authors.

More specialized are only Romania and Bulgaria. Furthermore, in all EU countries over the past decade the level of diversification increased, while in Ukraine it has not changed. Note also that despite the different level of sectoral diversification in the regions of Ukraine none of the regions showed the level that is inherent for countries EU15.

#### 1.4. Evaluation of regional employment diversification index for different sectors of economic activity

The degree of entropy of spatial diversification for employment in each sector in a particular country can be determined by Theil index using the formula

$$T_i = \sum_{r=1}^n \frac{e_{ri}}{e_i} \log \frac{e_i}{e_{ri}},$$

where  $e_{ri} = \frac{EMPL_{ri}}{\sum_r \sum_i EMPL_{ri}}$  – the share of employment in the  $i$ -sector of the  $r$ -region,  $e_i = \sum_r e_{ri}$  – the share of employment in the  $i$ -sector of the economy. The value  $T_i$  defines a concept opposite to the concept of geographic concentration of branches and takes a value 0 if  $i$  sector operates in one region only and the maximum value of  $\log(n)$ , where  $n$  – number of regions, if at all regions the share of employment in this sector is the same. Averaging at the national level for this index is

$$\bar{T} = \sum_{i=1}^m e_i \log \frac{1}{e_i}.$$

As a result of  $T_i$  coefficient division into theoretical maximum  $\log(n)$ , there can be obtained the normalized Theil index of diversification which reflects the rate of

employment among economic sectors in each region and takes a value in the interval [0, 1]. In particular, for normalized coefficients values which are close to 0 indicate an absolute geographic concentration of branch in one region and values close to 1 indicate the absolute geographic diversification of the branch.

Values of the index of regional employment diversification for different sectors of economic activity in Ukraine for various years are given in [Table 4](#).

**Table 4**

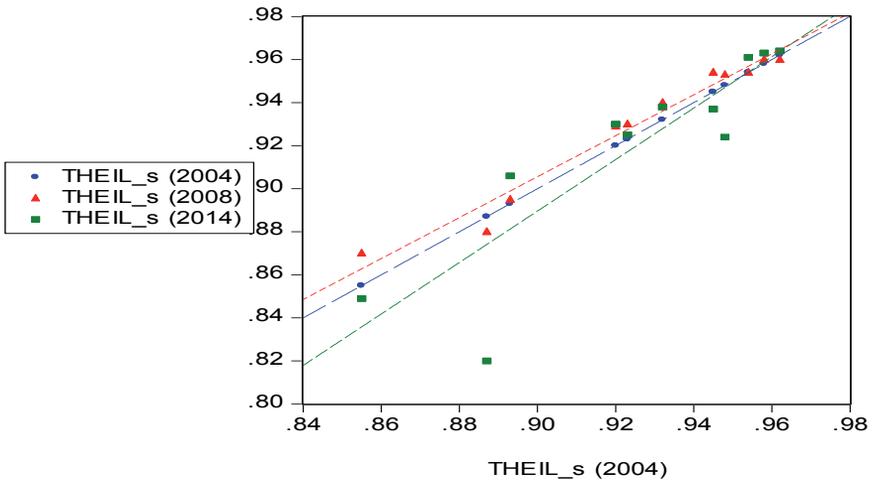
**Normalized index of regional employment unevenness for various economic activities in Ukraine**

Economy sector	2004	2008	2009	2013	2014
Agriculture, forestry and fishing	0.962	0.960	0.960	0.957	0,964
Industry	0.893	0.895	0.896	0.898	0,906
Construction	0.920	0.929	0.933	0.935	0,930
Trade, repair, accommodation and food service	0.932	0.940	0.942	0.939	0,938
Transportation and communication	0.923	0.930	0.935	0.924	0,925
Finance and insurance	0.887	0.880	0.865	0.827	0,820
Real estate, renting, professional and technical activities	0.855	0.870	0.864	0.855	0,849
Public administration and defense	0.945	0.954	0.953	0.939	0,937
Education	0.958	0.960	0.960	0.961	0,963
Human health	0.954	0.954	0.954	0.956	0,961
Averaged index	0.9483	0.9493	0.9499	0.9509	0,9524

**Source:** evaluations of the author.

The calculated values of diversification indexes for each branch by regions show that different economic sectors are characterized by a varying degree of geographic concentration that remains almost unchanged over time. Industry, financial and real estate sectors are the most geographically concentrated among all sectors while all the others are characterized by the high coefficient of Theil diversification.

While analyzing change of Theil coefficient over the last decade, it is clearly seen that among all sectors of the economy the geographical concentration of employed has intensified only in the financial sector and major changes have occurred over the 2008–2014. During this period in areas that in terms of employment covered a small fraction of the Ukrainian financial sector this share has decreased, while in areas with relatively large part of this sector this share has increased. As a result there can be observed an increase in the slope coefficient of the regression (Figure 9) and deepening of geographical concentration at the financial sector during 2008–2014.



**Figure 9.** Change of spatial diversification of employment by different economic sectors in Ukraine

**Source:** evaluations of the author.

In particular, the share of employees in financial sector of Dnipropetrovsk region increased from 8.4% to 9.3% while the average for Ukraine is 2.8%, and this growth occurred as long ago as during 2004–2008. Also the share of employees of the financial sector in Kiev region increased at 2.1% from 3.4% to 5.5% but unlike in Dnipropetrovsk region this growth took place continuously.

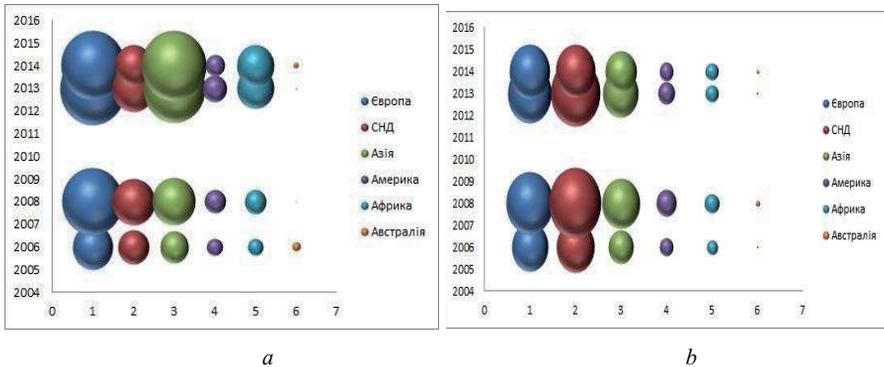
### 1.5. Evaluation of regional economic integration indices

To measure of economic integration degree of Ukraine's regions with different world area we determine the regional economic integration indices RIEI. The calculation we based on the volume of trade in goods and services. The index of economic integration with European countries at the national level for each sector ( $i$ ) and given year ( $t$ ) is

$$IEI(EUR)_{i,t} = \frac{TRADE(EUR)_{i,t}}{TOTALTRADE_{i,t}}, \quad (4)$$

where  $TRADE(EUR)_{i,t}$  – the trade volume (import and export) with European country for  $i$ -th sector in year  $t$ ;  $TOTALTRADE_{i,t}$  – the total trade of  $i$ -th sector in year  $t$ .  $IEI$  is in  $[0,1]$ , and is equal 0 if there is no economic integration and 1 if there is full economic integration.

Figure 10 shows the volume of trade in agricultural and industrial sectors with European countries in 2006, 2008 and 2013, 2014, as well as trade with the countries of the CIS, Asia, Africa, America and Australia. Statistics shows that exports and imports in the sectors of agriculture and industry have different distribution in different years.



**Figure 10.** Trade volume of: a) agriculture; b) industry

**Source:** data of the State Statistics Service of Ukraine, evaluation of authors.

Comparing the 2006, 2008 and 2013, we see that the dynamics of trade in agricultural products is characterized by a growing trend, and industrial trade volume in 2013 compared to 2008 decreased contrast. In addition, in 2013 in respect to previous years the share of trade in Ukraine agricultural production with Europe, America and CIS was the lowest, while with the countries of Asia and Africa the highest. In 2014 we see a decrease in trade for sector of agriculture with all countries (mainly due to the decrease in imports) and reducing the export and import industry with the CIS countries. The share of trade volumes with different groups of countries in 2014 compared to 2013, excluding the share of industry trade with the CIS countries, which fell significantly, almost unchanged.

In the absence of statistics for the trade with various countries at the regional level in order to determine the regional economic integration indices we calculate regional-sectoral location quotient [G. Petrakos, L. Topaloglou, 2008]

$$LQ_{ri} = (EMPL_{ri} / EMPL_r) / (EMPL_i / EMPL), \quad (5)$$

where  $EMPL_{ri}$  – the number of employees for  $i$ -th sector in  $r$ -th region;  $EMPL_r$  – the total number of employees in  $r$ -th region;  $EMPL_i$  – the total number of employees in  $i$ -th sector;  $EMPL$  – the total number of employees in Ukraine. Values of  $LQ_{ri}$  are greater

than 0. Values greater than 1 indicate that the part of  $i$ -th sector in the region is higher than in the country as a whole. The values of regional-sectoral location quotient in different Ukrainian regions in 2013 and 2016 are presented in Tables 5, 6.

Table 5

**Regional-Sectoral Location Quotients of Ukrainian Regions in 2013**

Region	Agriculture	Industry	Construction	Trade	Transport	Finance	Estate	Government	Agriculture	Industry
Crymea	1,15	0,56	0,86	1,23	0,85	0,69	1,07	1,10	0,84	1,30
Vinnitsia	1,88	0,67	0,61	0,80	0,88	0,66	0,58	1,01	1,08	1,10
Volyn	1,52	0,76	0,71	0,94	0,76	0,82	0,59	0,97	1,28	1,05
Dnipropetrovsk	0,40	1,64	0,87	1,12	1,05	1,24	0,96	0,90	0,92	0,89
Donetsk	0,61	1,57	1,20	1,04	1,03	0,72	0,79	0,87	0,76	0,91
Zhytomyr	0,88	0,88	1,14	1,07	1,16	0,59	0,61	1,19	1,10	1,05
Zakarpattia	1,45	0,69	1,30	0,86	0,78	0,50	0,50	0,80	1,10	0,86
Zaporizhia	0,94	1,43	0,91	1,01	0,80	0,73	0,96	0,80	0,88	0,97
Ivano-Frankivsk	1,60	0,80	1,05	0,84	0,66	0,59	0,52	0,79	1,18	1,11
Kiev Obl.	0,40	1,11	0,97	0,96	1,44	1,50	1,51	1,35	0,98	1,25
Kirovohrad	1,75	0,78	0,84	0,78	0,98	0,43	0,65	0,85	1,05	1,02
Luhansk	0,74	1,48	0,93	1,18	0,93	0,54	0,56	0,81	0,82	0,926
Lviv	1,13	0,89	1,64	0,86	1,02	0,76	0,73	0,96	1,13	1,16
Mykolaiv	1,47	0,85	0,85	0,96	0,91	0,58	0,60	0,99	1,00	0,85
Odesa	0,92	0,55	1,02	1,08	1,61	0,97	1,15	1,10	1,05	0,96
Poltava	1,13	1,18	0,78	0,95	0,94	0,69	0,67	0,97	0,99	1,06
Rivne	1,08	0,82	1,12	1,15	0,87	0,58	0,54	0,81	1,18	1,07
Sumy	1,23	1,00	1,09	0,90	0,86	0,65	0,63	1,01	1,04	1,03
Ternopil	1,91	0,58	0,83	0,76	0,68	0,54	0,51	0,84	1,28	1,07
Kharkiv	0,77	1,21	0,99	1,04	1,05	0,81	1,54	0,85	1,00	0,91
Kherson	1,76	0,61	0,66	0,95	0,73	0,59	0,73	0,89	1,05	0,91
Cherkasy	1,59	0,90	1,14	0,79	0,83	0,78	0,63	0,87	1,03	1,07
Chernivtsi	1,56	0,63	1,14	0,89	0,73	0,56	0,55	0,76	1,11	1,02
Chernihiv	1,51	0,78	0,60	0,95	0,71	0,89	0,66	1,16	1,00	1,18
Kyiv	0,02	0,57	1,03	1,08	1,40	4,16	3,31	1,71	1,03	0,79
Sevastopol	0,15	0,80	1,76	1,05	0,89	0,75	1,43	1,54	1,08	1,08

Source: evaluation of authors.

Table 6

## Regional-Sectoral Location Quotients of Ukrainian Regions in 2016

Region	Agriculture	Industry	Construction	Trade	Transport	Finance	Estate	Government	Agriculture	Industry
Vinnitsia	1,81	0,71	0,61	0,81	0,88	0,66	0,57	1,01	1,10	1,14
Volyn	1,37	0,80	0,68	0,97	0,80	0,74	0,66	1,01	1,33	1,10
Dnipropetrovsk	0,42	1,62	0,89	1,11	1,02	1,25	0,95	0,93	0,91	0,92
Donetsk	0,69	1,50	1,24	1,13	1,03	0,59	0,67	0,75	0,69	0,87
Zhytomyr	0,87	0,87	0,96	1,04	1,14	0,62	0,62	1,34	1,12	1,10
Zakarpattia	1,45	0,71	1,32	0,90	0,77	0,47	0,48	0,79	1,06	0,86
Zaporizhia	0,92	1,39	0,96	1,00	0,80	0,75	1,00	0,88	0,87	1,01
Ivano-Frankivsk	1,66	0,78	1,12	0,83	0,64	0,56	0,51	0,77	1,16	1,10
Kiev Obl.	0,39	1,12	0,87	0,96	1,39	1,48	1,52	1,36	0,99	1,28
Kirovohrad	1,62	0,83	0,77	0,78	1,01	0,44	0,71	0,85	1,08	1,13
Luhansk	0,80	1,22	1,10	1,34	0,93	0,57	0,63	0,66	0,74	0,92
Lviv	1,07	0,93	1,58	0,87	1,03	0,77	0,79	0,96	1,13	1,18
Mykolaiv	1,57	0,85	0,85	0,90	0,88	0,54	0,57	1,06	0,97	0,87
Odessa	0,95	0,56	0,99	1,06	1,58	0,92	1,18	1,08	1,07	0,96
Poltava	1,17	1,20	0,76	0,90	0,96	0,68	0,67	0,96	0,98	1,09
Rivne	1,04	0,83	1,13	1,16	0,86	0,60	0,57	0,80	1,15	1,09
Sumy	1,32	0,99	1,21	0,82	0,86	0,63	0,61	1,02	1,04	1,04
Ternopil	1,83	0,58	0,78	0,78	0,70	0,53	0,54	0,91	1,27	1,14
Kharkiv	0,78	1,19	1,10	1,02	0,99	0,76	1,54	0,84	1,06	0,93
Kherson	1,71	0,62	0,68	0,96	0,72	0,60	0,76	0,95	1,06	0,95
Cherkasy	1,56	0,91	0,99	0,82	0,87	0,78	0,63	0,84	1,00	1,11
Chernivtsi	1,63	0,62	1,11	0,89	0,70	0,53	0,58	0,77	1,09	1,03
Chernihiv	1,41	0,79	0,56	0,95	0,74	0,93	0,73	1,25	1,00	1,22
Kyiv	0,02	0,52	0,98	1,11	1,40	4,03	3,23	1,82	1,00	0,76

Source: evaluation of authors.

Analysis of calculated quotients for different sectors in different regions of Ukraine shows that in each direction of economic activity there are several areas where LQ greater than 1. The largest contribution to employment in the agricultural sector belongs to Ternopil, Vinnitsia and Kherson regions for which the ratio LQ greater than

1.7 and Kirovograd, Khmelnytsky, Volyn, Zakarpattia, Ivano-Frankivsk, Mykolayiv, Cherkasy, Chernivtsi and Chernihiv regions, the rate of which fluctuate from 1.37 to 1.66. The least agriculture LQ are in Dnipropetrovsk and Kyiv region with factor of 0.4. Dnipropetrovsk, Donetsk, Luhansk, Zaporizhia, Kharkiv and Poltava regions (LQ from 1.2 to 1.6) dominate in industry employment, while in Zakarpattia, Odesa, Ternopil and Kherson regions LQ factor for the industry does not reach the value 0.7. The construction sector dominates in Lviv region (LQ = 1,58), and the transport sector – in Odesa and Kiev. The financial sector is concentrated in the Kiev city with LQ = 4,03 and in Dnipropetrovsk. Note that after 2014 regional sectoral allocation didn't change.

Regional economic integration indices we calculate by the formula

$$RIEI_{r,t} = \sum_{i=1}^m (IEI_{i,t} \times LQ_{ri,t}). \quad (6)$$

The calculated values of regional indices of economic integration of agriculture and industry for the regions of Ukraine in 2008, 2013 and 2016 are presented in [Tables 7, 8, 9](#) and shown in [Figures 11, 12](#).

Analysis of regional integration index ([Table 6](#)) shows that compared to 2008 in all regions of Ukraine the degree of integration of agriculture sector with Europe and the CIS weakened, while significantly increased with the countries of Asia and Africa ([Figure 11a, 11b](#)). However the industry sector during 2008-2013 demonstrates the significant temporal changes in regional indices RIEI ([Figure 12a, 12b](#)).

Table 7

## Regional indexes of economic integration in Ukrainian regions in 2008

Region	2008									
	agriculture					industry				
	EU	CIS	Asia	Africa	America	EU	CIS	Asia	Africa	America
Crymea	0,526	0,254	0,260	0,068	0,063	0,174	0,218	0,111	0,000	0,031
Vinnysia	0,763	0,368	0,377	0,098	0,091	0,219	0,274	0,140	0,000	0,039
Volyn	0,719	0,347	0,355	0,092	0,086	0,221	0,277	0,141	0,000	0,040
Dnipropetrovsk	0,196	0,095	0,097	0,025	0,023	0,474	0,594	0,303	0,000	0,085
Donetsk	0,231	0,112	0,114	0,030	0,028	0,477	0,597	0,305	0,000	0,085
Zhytomyr	0,375	0,181	0,185	0,048	0,045	0,275	0,344	0,176	0,000	0,049
Zakarpartia	0,716	0,346	0,354	0,092	0,085	0,196	0,245	0,125	0,000	0,035
Zaporizhia	0,361	0,174	0,178	0,046	0,043	0,437	0,548	0,279	0,000	0,078
Ivano-										
Frankivsk	0,674	0,325	0,333	0,087	0,080	0,255	0,320	0,163	0,000	0,046
Kiev Obl.	0,270	0,130	0,134	0,035	0,032	0,307	0,384	0,196	0,000	0,055
Kirovohrad	0,873	0,421	0,431	0,112	0,104	0,222	0,278	0,142	0,000	0,040
Luhansk	0,344	0,166	0,170	0,044	0,041	0,435	0,545	0,278	0,000	0,078
Lviv	0,460	0,222	0,227	0,059	0,055	0,259	0,324	0,165	0,000	0,046
Mykolaiv	0,684	0,330	0,338	0,088	0,082	0,244	0,306	0,156	0,000	0,044
Odessa	0,482	0,233	0,238	0,062	0,058	0,160	0,201	0,102	0,000	0,029
Poltava	0,511	0,247	0,253	0,066	0,061	0,347	0,435	0,222	0,000	0,062
Rivne	0,466	0,225	0,230	0,060	0,056	0,235	0,295	0,150	0,000	0,042
Sumy	0,503	0,243	0,248	0,065	0,060	0,302	0,378	0,193	0,000	0,054
Ternopil	0,754	0,364	0,373	0,097	0,090	0,195	0,244	0,124	0,000	0,035
Kharkiv	0,354	0,171	0,175	0,045	0,042	0,308	0,385	0,197	0,000	0,055
Kherson	0,873	0,421	0,431	0,112	0,104	0,172	0,216	0,110	0,000	0,031
Cherkasy	0,792	0,382	0,391	0,102	0,095	0,251	0,315	0,161	0,000	0,045
Chernivtsi	0,761	0,367	0,376	0,098	0,091	0,178	0,223	0,114	0,000	0,032
Chernihiv	0,658	0,318	0,325	0,085	0,079	0,248	0,311	0,159	0,000	0,044
Kyiv	0,526	0,254	0,260	0,068	0,063	0,174	0,218	0,111	0,000	0,031
Sevastopol	0,763	0,368	0,377	0,098	0,091	0,219	0,274	0,140	0,000	0,039

Source: evaluation of authors.

Table 8

## Regional indexes of economic integration in Ukrainian regions in 2013

Region	2013									
	agriculture					industry				
	EU	CIS	Asia	Africa	America	EU	CIS	Asia	Africa	America
Crymea	0,412	0,180	0,368	0,133	0,055	0,170	0,217	0,112	0,000	0,024
Vynnytsia	0,674	0,294	0,602	0,218	0,091	0,204	0,260	0,134	0,000	0,029
Volyn	0,545	0,238	0,487	0,176	0,073	0,231	0,294	0,152	0,000	0,033
Dnipropetrovsk	0,142	0,062	0,127	0,046	0,019	0,499	0,636	0,328	0,000	0,072
Donetsk	0,219	0,095	0,196	0,071	0,029	0,478	0,609	0,314	0,000	0,069
Zhytomyr	0,313	0,137	0,280	0,101	0,042	0,266	0,339	0,175	0,000	0,038
Zakarpattia	0,519	0,226	0,464	0,168	0,070	0,211	0,269	0,139	0,000	0,030
Zaporizhia	0,335	0,146	0,300	0,108	0,045	0,435	0,553	0,286	0,000	0,062
Ivano-										
Frankivsk	0,572	0,250	0,512	0,185	0,077	0,243	0,310	0,160	0,000	0,035
Kiev Obl.	0,143	0,062	0,128	0,046	0,019	0,339	0,431	0,222	0,000	0,048
Kirovohrad	0,627	0,273	0,561	0,203	0,084	0,238	0,303	0,156	0,000	0,034
Luhansk	0,264	0,115	0,236	0,085	0,036	0,451	0,574	0,296	0,000	0,065
Lviv	0,405	0,177	0,363	0,131	0,055	0,272	0,346	0,178	0,000	0,039
Mykolaiv	0,526	0,230	0,471	0,170	0,071	0,260	0,331	0,171	0,000	0,037
Odessa	0,330	0,144	0,296	0,107	0,044	0,167	0,213	0,110	0,000	0,024
Poltava	0,405	0,176	0,362	0,131	0,054	0,358	0,456	0,235	0,000	0,051
Rivne	0,385	0,168	0,344	0,125	0,052	0,248	0,316	0,163	0,000	0,036
Sumy	0,442	0,193	0,395	0,143	0,059	0,304	0,387	0,200	0,000	0,044
Ternopil	0,683	0,298	0,611	0,221	0,092	0,176	0,225	0,116	0,000	0,025
Kharkiv	0,275	0,120	0,246	0,089	0,037	0,368	0,468	0,242	0,000	0,053
Kherson	0,630	0,275	0,563	0,204	0,085	0,186	0,237	0,122	0,000	0,027
Cherkasy	0,568	0,248	0,508	0,184	0,076	0,275	0,350	0,180	0,000	0,039
Chernivtsi	0,559	0,244	0,500	0,181	0,075	0,191	0,243	0,125	0,000	0,027
Chernihiv	0,542	0,236	0,484	0,175	0,073	0,237	0,301	0,155	0,000	0,034
Kyiv	0,412	0,180	0,368	0,133	0,055	0,170	0,217	0,112	0,000	0,024
Sevastopol	0,674	0,294	0,602	0,218	0,091	0,204	0,260	0,134	0,000	0,029

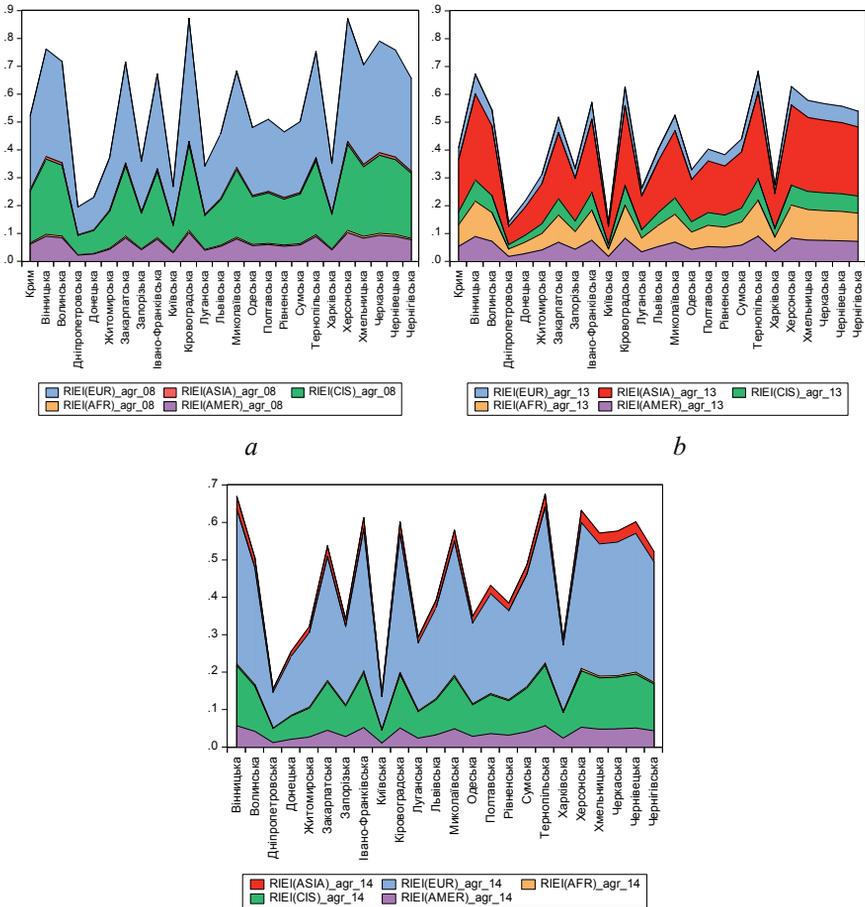
Source: evaluation of authors.

Table 9

## Regional indexes of economic integration in Ukrainian regions in 2016

Region	2016									
	agriculture					industry				
	EU	CIS	Asia	Africa	America	EU	CIS	Asia	Africa	America
Vinnitsia	0,636	0,218	0,670	0,223	0,058	0,258	0,243	0,150	0,000	0,030
Volyn	0,480	0,164	0,506	0,168	0,043	0,291	0,273	0,169	0,000	0,034
Dnipropetrovsk	0,148	0,051	0,156	0,052	0,013	0,592	0,556	0,344	0,000	0,069
Donetsk	0,244	0,084	0,257	0,086	0,022	0,548	0,514	0,318	0,000	0,064
Zhytomyr	0,307	0,105	0,323	0,108	0,028	0,317	0,298	0,184	0,000	0,037
Zakarpattia	0,510	0,175	0,538	0,179	0,046	0,259	0,244	0,151	0,000	0,030
Zaporizhia	0,324	0,111	0,342	0,114	0,029	0,508	0,477	0,295	0,000	0,059
Ivano-Frankivsk	0,583	0,199	0,614	0,204	0,053	0,285	0,268	0,166	0,000	0,033
Kiev Obl.	0,137	0,047	0,145	0,048	0,012	0,410	0,385	0,238	0,000	0,048
Kirovohrad	0,571	0,195	0,602	0,200	0,052	0,304	0,286	0,177	0,000	0,035
Luhansk	0,280	0,096	0,295	0,098	0,025	0,446	0,419	0,259	0,000	0,052
Lviv	0,375	0,128	0,395	0,131	0,034	0,338	0,317	0,196	0,000	0,039
Mykolaiv	0,551	0,188	0,580	0,193	0,050	0,311	0,292	0,181	0,000	0,036
Odessa	0,333	0,114	0,351	0,117	0,030	0,204	0,191	0,118	0,000	0,024
Poltava	0,411	0,141	0,433	0,144	0,037	0,437	0,410	0,254	0,000	0,051
Rivne	0,366	0,125	0,386	0,128	0,033	0,304	0,285	0,176	0,000	0,035
Sumy	0,464	0,159	0,489	0,163	0,042	0,360	0,339	0,209	0,000	0,042
Ternopil	0,643	0,220	0,677	0,225	0,058	0,212	0,199	0,123	0,000	0,025
Kharkiv	0,274	0,094	0,288	0,096	0,025	0,435	0,409	0,253	0,000	0,051
Kherson	0,601	0,205	0,633	0,211	0,054	0,224	0,211	0,130	0,000	0,026
Cherkasy	0,549	0,188	0,578	0,192	0,050	0,332	0,312	0,193	0,000	0,039
Chernivtsi	0,572	0,196	0,603	0,201	0,052	0,224	0,211	0,130	0,000	0,026
Chernihiv	0,496	0,170	0,523	0,174	0,045	0,289	0,271	0,168	0,000	0,034

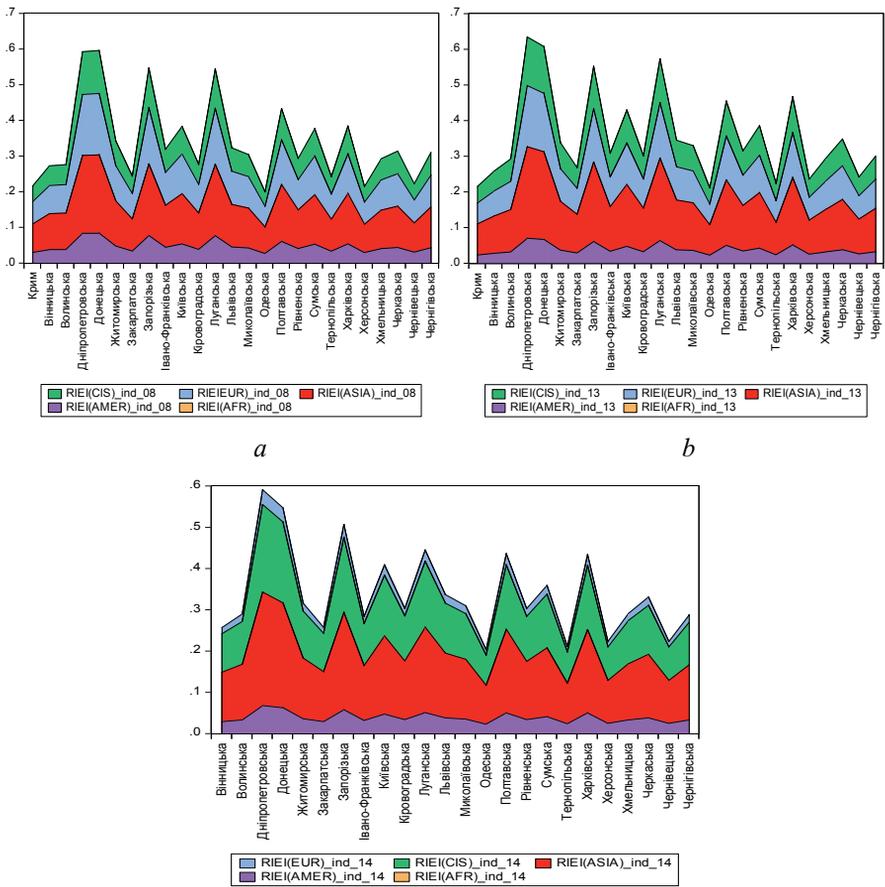
Source: evaluation of authors.



**Figure 11.** Regional indexes of economic integration for agriculture in Ukrainian regions: a) in 2008; b) in 2013; c) in 2016.

**Source:** evaluation of authors.

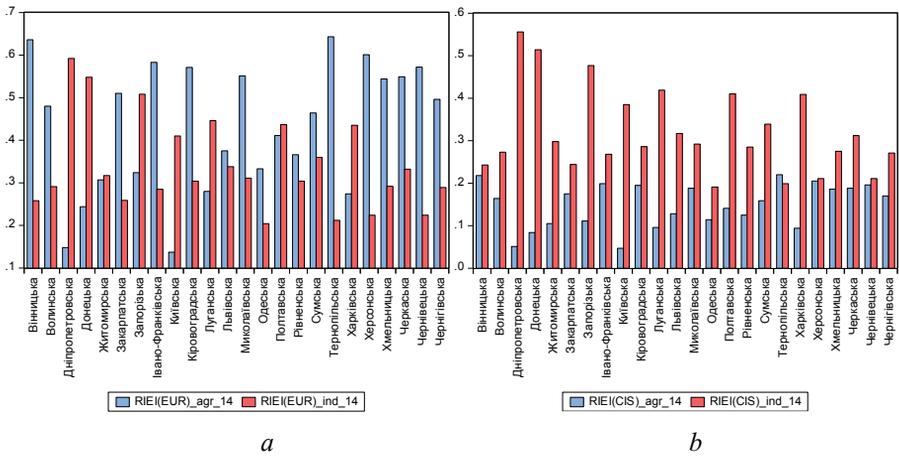
In 2016 the level of regional agriculture integration with Asia reached the respective levels of integration with Europe and Africa RIEI, and in some areas even exceeded the values with CIS countries. (4.1.11 $\epsilon$ ). Also in 2016 there was a change in the regional economic integration indices of industry. In particular, the highest index value is obtained in this year for Europe. (4.1.12 $\epsilon$ ).



**Figure 12.** Regional indexes of economic integration for industry in Ukrainian regions: a) in 2008; b) in 2013; c) in 2015.

**Source:** evaluation of authors.

Figure 13 depicts the calculated indices of economic integration of agriculture and industry with the economies of European countries and similarly defined indices of integration with the economy of the CIS countries in 2016.



**Figure 13.** Regional indexes of economic integration for agriculture and industry with: a) EU; b) CIS in 2015.

**Source:** evaluation of authors.

Comparing the integration levels of agriculture sector and industry in terms of employment shows that most regions of Ukraine, except six industrial regions (Dnipropetrovsk, Donetsk, Zaporizhia, Kyiv, Luhansk, Kharkiv regions) are more integrated with Europe for agriculture sector (Figure 13a). At the same time exploring the integration degree of the Ukrainian regions with the CIS countries we get the opposite result – for most regions index integration of industry with these countries is much greater than the corresponding index of agriculture integration (Figure 13b). Note also that in 4 regions (Chernovtsy, Vinnitsa, Kherson and Ternopil) the total RIEI for agriculture is almost three times higher than RIEI for industry, and for another 10 areas RIEI are twice. Overall analysis of regional integration index found that agriculture regions of Ukraine are more integrated with Europe, while industry – with CIS countries.

## 1.6. Evaluation of the geographical attractiveness of the regions

Index geographical attractiveness of region we define under gravity index formula [D. Kallioras, G. Petrakos, 2010]

$$GRAVITY_r = \sum_j (POP_r \times POP_j / d_{rj}), \quad (7)$$

where  $POP_r$  – population in  $r$ -th region, for with we calculate  $GRAVITY$  index;  $POP_j$  – population in  $j$ -th region ( $j=1, \dots, 25, j \neq r$ );  $d_{rj}$  – the distance between the centers of the  $r$ -th and  $j$ -th regions.

$GRAVITY$  index takes values greater than 0 and reflects the degree of geographic accessibility and market potential of each region. The indices of geographical periphery of the Ukrainian regions is determined on the basis of (7) for various years are given in Table 10 and shown in Figure 14. Analysis of regional  $GRAVITY$  index showed the most accessible and geographically attractive the Dnipropetrovsk, Donetsk, Kharkiv, Zaporizhia, Lviv and Odessa, Luhansk, Kyiv region in relation to other regions of Ukraine, while Chernivtsi, Sumy, Chernivtsi and Chernihiv regions have the lowest indices.

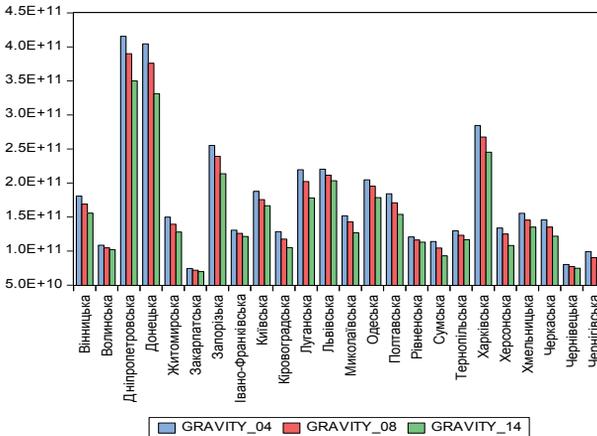


Figure 14. Geographical attractiveness index of region

Source: evaluation of authors.

Table 10

**Geographical attractiveness index of region**

Region	2004	2008	2013	2014
Crymea	1,37E+11	1,31E+11	1,27E+11	—
Vynnytsia	1,81E+11	1,69E+11	1,61E+11	1,56E+11
Volyn	1,09E+11	1,05E+11	1,04E+11	1,02E+11
Dnipropetrovsk	4,16E+11	3,90E+11	3,70E+11	3,50E+11
Donetsk	4,04E+11	3,76E+11	3,53E+11	3,31E+11
Zhytomyr	1,50E+11	1,39E+11	1,33E+11	1,28E+11
Zakarpattia	7,44E+10	7,19E+10	7,14E+10	6,99E+10
Zaporizhia	2,55E+11	2,39E+11	2,27E+11	2,14E+11
Ivano-Frankivsk	1,31E+11	1,26E+11	1,24E+11	1,22E+11
Kiev Obl.	1,88E+11	1,76E+11	1,70E+11	1,67E+11
Kirovohrad	1,29E+11	1,18E+11	1,10E+11	1,05E+11
Luhansk	2,20E+11	2,02E+11	1,88E+11	1,78E+11
Lviv	2,20E+11	2,11E+11	2,07E+11	2,03E+11
Mykolaiv	1,52E+11	1,43E+11	1,36E+11	1,27E+11
Odessa	2,05E+11	1,95E+11	1,91E+11	1,79E+11
Poltava	1,84E+11	1,71E+11	1,61E+11	1,54E+11
Rivne	1,21E+11	1,16E+11	1,15E+11	1,13E+11
Sumy	1,14E+11	1,05E+11	9,75E+10	9,31E+10
Ternopil	1,30E+11	1,23E+11	1,19E+11	1,17E+11
Kharkiv	2,84E+11	2,68E+11	2,55E+11	2,45E+11
Kherson	1,34E+11	1,25E+11	1,19E+11	1,08E+11
Cherkasy	1,46E+11	1,35E+11	1,27E+11	1,22E+11
Chernivtsi	8,05E+10	7,74E+10	7,63E+10	7,48E+10
Chernihiv	9,94E+10	9,06E+10	8,41E+10	8,09E+10
Kyiv	1,37E+11	1,31E+11	1,27E+11	1,30E+11
Sevastopol	1,81E+11	1,69E+11	1,61E+11	—

**Source:** evaluation of authors.

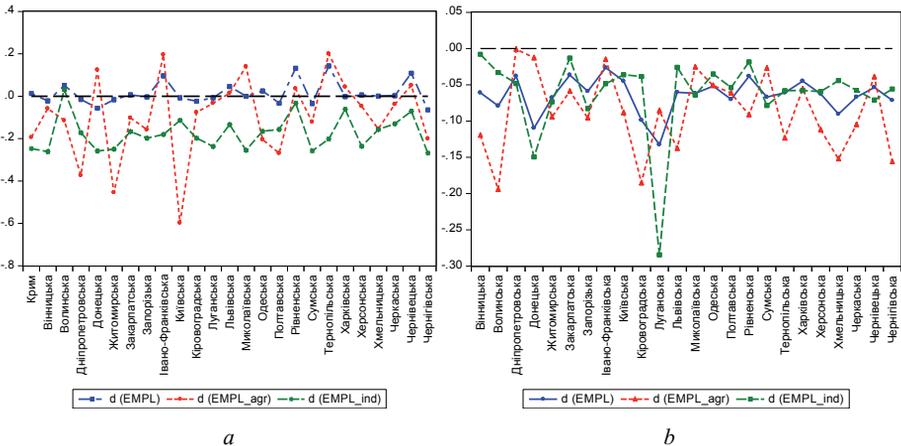
## CHAPTER 2

# ECONOMETRIC MODELING OF UKRAINIAN REGIONAL EMPLOYMENT AND ESTIMATION OF INTEGRATION PROCESSES IMPACT

### 2.1. Econometrics models for changes in regional nominal employment, regional employment in agriculture and industry

We conducted also the features research and econometric modeling of dynamic changes in regional employment and productivity.

Empirical research of nominal employment in different regions of Ukraine for the past 10 years reveals significant regional differences in the dynamics of changes in total employment rate and the number of employees in various sectors (Figure 15).



**Figure 15.** Changes in regional nominal employment in period a) till 2004; b) 2014 - 2016

**Source:** data of the State Statistics Service of Ukraine, evaluation of authors.

Table 11

**Characteristics of the percentage change in employment in the regions of  
Ukraine, 2004 – 2016**

Characteristics	Percentage change in total employment	Percentage change in agriculture employment	Percentage change in industry employment
Mean	-0,055217	-0,216251	-0,259587
Median	-0,061592	-0,168564	-0,243927
Maximum	0,084570	0,163315	-0,003802
Minimum	-0,174262	-1,003302	-0,605819
Std. Dev.	0,068575	0,262620	0,130197
Skewness	0,507263	-1,151290	-0,471559
Kurtosis	2,735898	4,760967	3,707068
Jarque-Bera	1,099011	8,402882	1,389417
Probability	0,577235	0,014974	0,499220
Sum	-1,325196	-5,190035	-6,230079
Sum Sq. Dev.	0,108159	1,586289	0,389881

**Source:** evaluation of authors.

In particular, during 2004–2013 in half of the regions, despite falling population, we saw an increase in the nominal employment (among others, in the Ternopil region by 14.2%, Rivne - 13.1%, Chernivtsi - 10.8%, Ivano-Frankivsk - 9.6%, Volyn - 5.1%, Lviv - 4.5%, Odessa - 2.4%), although in some regions the total employment decreased (most in Chernihiv (-6.5%) and Donetsk (-5.7%) regions). However, the dynamics of the number of employees in the industry is caused by negative growth rate, which is an average of -7.5% in all regions of Ukraine. The percentage change in employment in regional agriculture is characterized by greater compared to total employment and employment in the industry, and a large variation of left-sided asymmetry. Increasing the number of people employed in the agricultural sector (about 9%) occurred only in third regions of Ukraine (Lviv, Rivne, Kharkiv, Chernivtsi, Donetsk, Mykolaiv, Ivano-Frankivsk and Ternopil), has undergone significant agriculture changes in Kyiv (-59, 7%), Zhytomyr (-45.5%) and Dnipropetrovsk (-37.4%) regions, whereas other regions falling in agriculture employment rate ranged from -3% to -27%. In 2016 we saw a

drop in total employment and the number of people employed in agriculture and industry for all regions of Ukraine (Figure 15b).

To model the changes in regional employment in general, as well as in the sectors of agriculture and industry in particular we use econometric models. Based on the economic and mathematical analysis, evaluating and comparing the various econometric models we chose such specifications:

$$\begin{aligned} \Delta \ln EMPL_r = & \alpha_1 + \alpha_2 E04\_agr_r + \alpha_3 EMPL04\_agr_r / POP04_r + \alpha_4 \Delta RIEI(EUR)\_ind_r + \\ & + \alpha_5 \Delta RIEI(CIS)\_ind_r + \alpha_6 (\Delta RIEI(EUR)\_agr_r + \Delta RIEI(CIS)\_agr_r) + \\ & + \alpha_7 (\Delta RIEI(ASIA)\_agr_r + \Delta RIEI(AFR)\_agr_r) + \alpha_8 \ln GRAVITY04_r + \\ & + \alpha_9 \Delta THEIL_r + \varepsilon_{1r}, \end{aligned} \quad (8)$$

$$\begin{aligned} \Delta \ln EMPL\_agr_r = & \beta_1 + \beta_2 E04\_agr_r + \beta_3 E04\_serv_r + \beta_4 EMPL04\_agr_r / POP04_r + \\ & + \beta_5 (\Delta RIEI(EUR)\_agr_r + \Delta RIEI(CIS)\_agr_r) + \\ & + \beta_6 (\Delta RIEI(ASIA)\_agr_r + \Delta RIEI(AFR)\_agr_r) + \\ & + \beta_7 \ln GRAVITY04_r + \beta_8 \Delta THEIL_r + \varepsilon_{2r}, \end{aligned} \quad (9)$$

$$\begin{aligned} \Delta \ln EMPL\_ind_r = & \gamma_1 + \gamma_2 E04\_ind_r + \gamma_3 E04\_serv_r + \gamma_4 EMPL04\_ind_r / POP04_r \\ & + \gamma_5 \Delta RIEI(EUR)\_ind_r + \gamma_6 RIEI08(CIS)_r + \gamma_7 RIEI08(ASIA)_r + \\ & + \gamma_8 \ln GRAVITY04_r + \gamma_9 \Delta THEIL_r + \varepsilon_{3r}. \end{aligned} \quad (10)$$

Here  $EMPL04_r$  define the total employment in  $r$ -th region in initial 2004;  $POP04_r$  – population of  $r$ -th region in 2004;  $E04\_agr_r$  – the agriculture share in  $r$ -th region in 2004;  $E04\_ind_r$  – the industry share in  $r$ -th region in 2004;  $E04\_serv_r$  – the service sector share in  $r$ -th region. Variable  $RIEI(EUR)_r$ ,  $RIEI(CIS)_r$ ,  $RIEI(ASIA)_r$ ,  $RIEI(AFR)_r$  denote economic integration indices of  $r$ -th region with Europe, CIS, Asia and Africa countries respectively.  $\Delta RIEI_r$  – change in the index of economic integration in the  $r$ -th region for the period 2008 to 2015. Variable  $\Delta THEIL_r$  characterizes the change in the index of diversification (specialization) employment in various sectors of  $r$ -th

region during 2004-2015 years and  $GRAVITY04_r$  variable indicates the geographical attractiveness index  $r$ -th region in 2004.

The estimates of the models parameters determine the impact of differences in geographical location of the region, the initial level of employment, the share of individual sectors, the degree of economic integration and diversification index of economic sectors in the region to the change in nominal employment in the region and also in regional employment in agriculture and industry.

Obtained as a result of the evaluation on the basis of real data, the parameter estimations for models (8) – (10) and the corresponding values of Student's statistics are given in [Table 12](#).

Analyzing the impact of exogenous variables on regional employment change, we found that the initial share of the region in the agricultural sector of Ukraine is a significant factor that has influence to the future dynamics of the number of employees in the region. Regions that are characterized by higher initial (2004) share of agriculture sector, showed during the years 2004 – 2015 total employment growth, but that was accompanied by decreasing the number of employees in agriculture. Instead, the initial share of industry in the region had no significant effect on change in total employment and agriculture employment, but the negative impact on employment change in the industry. The results indicate that the industrial sector in the regions in which its share in terms of lower can better withstand external and internal instability of the economic environment and structural changes in the economy. However, higher initial share of employment in services in the region provided the other conditions of equality and promotes agriculture and industry growth rate and the growth of employment and development of these sectors.

The increase in employment in the region depends inversely on the proportion of employment in agriculture sector the region in the structure of the region's population, and its increase of 1% causes the decrease in growth rate of total employment by 0.06%.

Table 12

## Estimation results for model (8) – (10)

Variable	Equation for					
	$\Delta \ln EMPL$		$\Delta \ln EMPL_{agr}$		$\Delta \ln EMPL_{ind}$	
	Coef.	t-Statistic (p-value)	Coef.	t-Statistic (p-value)	Coef.	t-Statistic (p-value)
Const	0,5782	1,126 (0,2769)	1,6310	0,861 (0,4013)	0,2773	0,327 (0,7477)
$E04_{agr}$	0,0256	5,683*** (0,0000)	-0,0624	-2,876** (0,0105)	—	—
$E04_{ind}$	—	—	—	—	-0,0266	-1,835* (0,0850)
$E04_{serv}$	—	—	0,0086	2,232** (0,0394)	0,0107	2,862** (0,0113)
$EMPL04_{agr} / POP04$	-0,0634	- 6,149*** (0,0000)	0,0059	0,156 (0,8782)	—	—
$EMPL04_{ind} / POP04$	—	—	—	—	-0,0954	-4,371*** (0,0005)
$\Delta RIEI(EUR)_{ind}$	0,1643	2,543** (0,0217)	—	—	0,0317	4,999*** (0,0001)
$\Delta RIEI(CIS)_{ind}$	-0,1271	-2,556** (0,0211)	—	—	—	—
$RIEI08(CIS)$	—	—	—	—	0,0751	7,442** (0,0000)
$RIEI08(ASIA)$	—	—	—	—	-0,0707	-7,630*** (0,0000)
$\Delta RIEI(EUR)_{agr+}$	0,0012	1,564 (0,1374)	-0,0190	-7,47*** (0,0000)	—	—
$\Delta RIEI(CIS)_{agr}$	—	—	—	—	—	—
$\Delta RIEI(ASIA)_{agr+}$	-0,0019	-1,554 (0,1397)	0,0566	5,924*** (0,0000)	—	—
$\Delta RIEI(AFR)_{agr}$	—	—	—	—	—	—
$\ln GRAVITY04$	-0,0164	-0,833 (0,4171)	-0,0859	-1,223 (0,2382)	-0,0490	-1,262 (0,2250)
$\Delta Theil$	-0,3973	-2,907** (0,0103)	0,8986	1,279 (0,2180)	-0,0926	-0,580 (0,5696)

**Note:** \*\*\*, \*\* and \* define the significancy at the level for 99%, 95% and 90% respectively.

**Source:** estimation of authors.

Table 13 shows the value of the adjusted determination coefficients, Fischer statistics and the results of testing the residuals heteroscedasticity of the model (8) – (10) based on the White and Breus-Pagan-Godfrey tests. The obtained values of statistical criteria and their p-values indicate the homoskedasticity of their residues and the adequacy of the constructed models.

Table 13

**Diagnostic results of model (8) – (10)**

<i>R</i> -squared	0,8336	0,9076	0,9077
Adjusted <i>R</i> -squared	0,7504	0,8695	0,8616
<i>F</i> -Statistic	10,019 (0,000)	23,851 (0,000)	19,669 (0,000)
White-Statistic	0,4876 (0,847)	0,3072 (0,940)	1,4256 (0,259)
<i>BPG</i> —Statistic	0,6115 (0,755)	1,1971 (0,355)	1,3799 (0,277)

**Note:** p-value in parenthesis ().

**Source:** estimation of authors.

The modeling results also showed that a higher index of regional industry integration with Europe will help increase employment in the region, while higher levels of industrial integration with the CIS region opposite the deteriorating situation on the regional labor market. The level of integration of the agricultural sector doesn't change the employment in general, but is a significant factor in changing agriculture employment. Note that the agriculture which intensified trade relations with Asia and Africa tend to employment growth, while expanding integration with Europe and the CIS makes its decline. In addition, a significant factor influencing the growth of regional employment in the industry is the initial index level of economic integration in the CIS industry, before the crisis set in 2008.

Growth in factor diversification Theil index is a significant factor in the changes in employment, confirming the importance of regional specialization in employment growth in the region. The negative estimated value revealed that regional

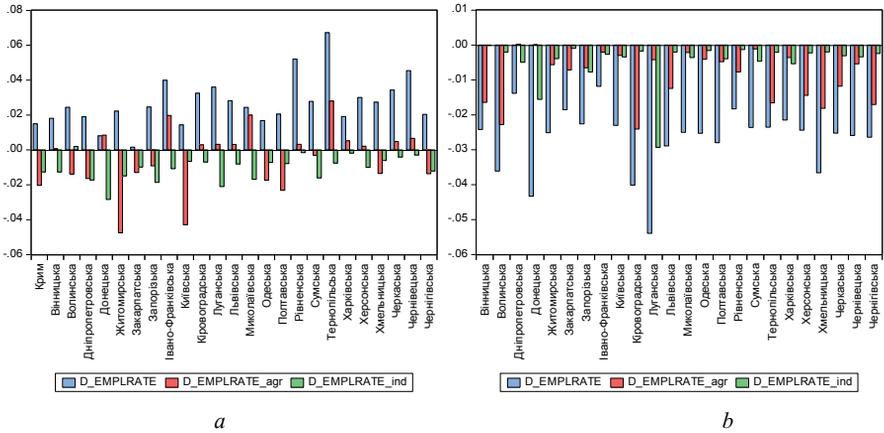
diversification in Ukraine does not allow muffle inherent in every industry shocks arising from integration processes, crisis and instability of the situation, but rather increase the impact of storms and weaken the economy in general.

Meanwhile, the index of gravity is not a statistically significant factor in any of the models suggests not that the geographical location of the region has no influence on the dynamic changes in regional employment.

## **2.2. Econometric modeling of changes in regional employment rate in the context of dynamic changes in the processes of economic integration**

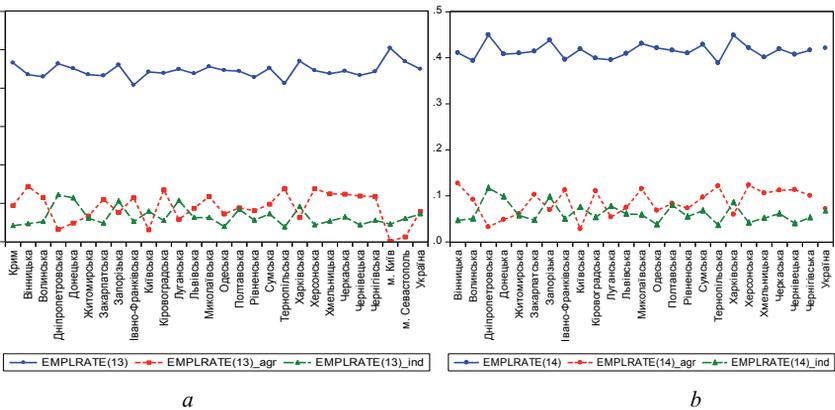
The next step is conducting an econometric study of the influence of economic integration on change of employment rate and economic activity of population in the Ukrainian regions. Empirical study of employment level changes in various regions for the last 10 years detects specific regional differences in the dynamics of labor demand, employment rate in general and in various economic sectors in particular. Should be noted that in all regions along with the growth of unemployment can be observed an increase in economic activity of population and the overall level of employment on the average from 41% to 44% of the region population. The following regions are characterized by the highest revival of the labor market: Ternopil (+6.7%), Rivne (+5.2%), Chernivtsi (+4.5%), Ivano-Frankivsk (+3.9%), Luhansk (+3.6%) and Cherkasy (+3.4%). However, the level of employment in industry is characterized by a negative shift in all regions of Ukraine (except Volyn region) on average about 1% (from 7.6% to 6.6%). Instead, change of employment level in the agricultural sector in Ukrainian regions shows significant heterogeneity between (-5% up to +3%). In particular about half of regions had a slight increase in employment in agriculture (on the average by 0.4% from 9.7% to 10.5%), while other regions on contrary had a reduction in agricultural employment (on the average by 1, 9% from 10.4% to 8.5%). The following regions have undergone a significant decrease in the level of agricultural

employment: Zhytomyr (-4.7%), Kyiv (-4.3%) and Poltava (-2.3%) regions (Figure 16,17).



**Figure 16.** Changes of population employment rate for regional labor markets in a) 2004–2013; b) 2014 – 2015.

**Source:** data of the State Statistics Service of Ukraine, elaborations of the author



**Figure 17.** Population employment rate for regional labor markets in a) 2013; b) 2015.

**Source:** data of the State Statistics Service of Ukraine, elaborations of the author

In 2014, the employment rate has dropped significantly in all regions of Ukraine (an average of -2.7%). At the same time, the downturn was primarily attributable to the Luhansk (-5.4%) and Donetsk (-4.3%) regions, as well as to a significant decrease in Kirovograd (-4.1%), Khmelnytsky (-3.7%), Volyn (-3.6%) oblast and in the Kyiv city (-3.0%). The smallest changes in the level of employment are observed in Kharkiv (-2.1%), Transcarpathian (-1.9%), Rivne (-1.8%), Dnipropetrovsk (-1.4%) and Ivano-Frankivsk (-1.2 %) areas (Figures 16b, 17b).

For modeling changes in the regional employment level generally and in agriculture and industry sectors after estimation and comparison of different econometric specifications the following models has been chosen

$$\begin{aligned} \Delta EMPLRATE_r = & \alpha_1 + \alpha_2 GRAVITY04_r + \alpha_3 \Delta THEIL_r + \alpha_4 EMPLRATE04_r + \\ & + \alpha_5 RIEI08(EUR)_r + \alpha_6 RIEI08(CIS)_r + \alpha_7 \Delta RIEI(EUR)_r + \\ & + \alpha_8 \Delta RIEI(CIS)_r + \varepsilon_{1r}, \end{aligned} \quad (11)$$

$$\begin{aligned} \Delta EMPLRATE_{agr_r} = & \beta_1 + \beta_2 GRAVITY04_r + \beta_3 \Delta THEIL_r + \beta_4 EMPLRATE04_r + \\ & + \beta_5 RIEI08(EUR)_r + \beta_6 RIEI08(CIS)_r + \beta_7 \Delta RIEI(EUR)_r + \\ & + \beta_8 \Delta RIEI(CIS)_r + \varepsilon_{2r}, \end{aligned} \quad (12)$$

$$\begin{aligned} \Delta EMPLRATE_{ind_r} = & \gamma_1 + \gamma_2 GRAVITY04_r + \gamma_3 \Delta THEIL_r + \gamma_4 EMPLRATE04_r + \\ & + \gamma_5 RIEI08(EUR)_r + \gamma_6 RIEI08(CIS)_r + \gamma_7 \Delta RIEI(EUR)_r + \\ & + \gamma_8 \Delta RIEI(CIS)_r + \varepsilon_{3r}. \end{aligned} \quad (13)$$

Here  $EMPLRATE04_r = EMPL04_r / POP04_r$  indicates the level of employment in the  $r$ -region in early 2004;  $EMPL04_r$  – number of employees in  $r$ -region in 2004 (thousand people);  $POP04_r$  – population of  $r$ -region in 2004 (thousand people);  $\Delta EMPLRATE_r$  – changes in the general level of employment in the  $r$ -region for the period from 2004 to 2014;  $\Delta EMPLRATE_{agr_r}$  i  $\Delta EMPLRATE_{ind_r}$  – changes of the employment level in agriculture and industry sectors respectively in the  $r$ -region during the period from 2004 to 2014. Variables  $RIEI08(EUR)_r$ ,  $RIEI08(SND)_r$  and

$\Delta RIEI(EUR)_r$ ,  $\Delta RIEI(SND)_r$  denote the indexes of  $r$ -regional economic integration with the European countries and the CIS in 2008 and changes of their values from 2008 to 2014. In particular, the regional indexes of economic integration with the European countries in  $t$ -year are determined by the formula (D. Kallioras and G. Petrakos, 2010)

$$RIEI(EUR)_{r,t} = \sum_{i=1}^m \left( \frac{TRADE(EUR)_{i,t}}{TOTALTRADE_{i,t}} \right) \times \left( \frac{EMPL_{ir,t}}{EMPL_{r,t}} \right) / \left( \frac{EMPL_{i,t}}{EMPL_t} \right).$$

where  $TRADE(EUR)_{i,t}$  – trade volume (import and export in value terms) of the  $i$ -economy sector with the European countries in  $t$ -year;  $TOTALTRADE_{i,t}$  – total volume of trade of the  $i$ -sector with the world in  $t$ -year;  $EMPL_{ir}$  – number of employees in the  $i$ -sector of  $r$ -region in  $t$ -year;  $EMPL_r$  – the total number of people employed in the  $r$ -region in year  $t$ ;  $EMPL_i$  – the total number of people employed in the  $i$ -sector of the economy in year  $t$ ;  $EMPL$  – the total number of employees in the country in  $t$ -year. Economic integration indexes for the CIS countries are defined similarly. The calculated values of economic integration indexes for agriculture and industry in various regions of Ukraine in 2008, 2013, 2016 are presented in Table 7 – 9.

Variable  $\Delta THEIL_r$  describes the change in the index of employment diversification according to various economy sectors in the  $r$ -region during 2004–2014 years. Variable  $GRAVITY04_r$  denotes an index of geographical attractiveness of  $r$ -region and is calculated as an gravity index by formula

$$GRAVITY_r = \sum_j (POP_r \times POP_j / d_{rj}),$$

where  $POP_r$  – population of  $r$ -region;  $POP_j$  – population of  $j$ -region ( $j=1, \dots, 25, j \neq r$ );  $d_{rj}$  – distance between the centers of the  $r$ -region and  $j$ -region.

Parameters estimates of models (11)–(13) determine the degree of influence of regional geographical location, initial of employment, changes in index of diversification sectors of the economy in the region, as well as initial levels of

economic integration with the European countries and the CIS and their changes in response to changing the level of employment in the region and the level of regional employment in agriculture and industry. The results of parameters estimation, corresponding values of Student's statistics and their p-value are given in Table 14.

**Table 14**

**Estimation Results of Models (11)–(13)**

Variable	Equations for					
	$\Delta EMPLRATE$		$\Delta EMPLRATE_{agr}$		$\Delta EMPLRATE_{ind}$	
	Coefficient	t-Statistic (p-value)	Coefficient	t-Statistic	Coefficient	t-Statistic
<i>Const</i>	0.2280	6.6220*** (0.0000)	0.0126	0.3686 (0.7169)	0.0482	3.0680*** (0.0070)
<i>GRAVITY04</i>	-1.3E-15	-0.0448 (0.9647)	8.4E-14	1.3372 (0.1988)	-5.6E-15	-0.3071 (0.7625)
$\Delta THEIL$	-0.0614	-1.8101* (0.0880)	-0.2087	-	0.0390	1.3240 (0.2030)
$\log EMPLRATE04$	-0.5030	-	-0.2126	-	-0.1105	-
<i>RIEI08(EUR)</i>	0.00017	5.8399*** (0.0000)	0.0015	2.9541*** (0.0089)	0.0007	3.2583*** (0.0046)
<i>RIEI08(CIS)</i>	-2.3E-06	0.6814 (0.5048)	-0.0008	4.1689*** (0.006)	-0.0010	5.2835*** (0.0001)
$\Delta REIE(EUR)$	-0.00039	-0.0077 (0.9939)	0.0004	-1.9029* (0.0741)	-0.0011	-
$\Delta REIE(CIS)$	0.0016	-0.7180 (0.4825)	0.0023	0.526294 (0.6055)	0.0031	4.5418*** (0.0003)
		1.7824* (0.0925)		1.7821* (0.0926)		7.9346*** (0.0000)

**Note:** \*\*\*, \*\* and \* indicate significance of the coefficients at 1%, 5% and 10% levels.

**Source:** estimation of the author.

Values of adjusted R-squared coefficients, F-statistics and testing results of heteroscedasticity (11)–(13) based on White and Breusch-Pagan-Godfrey test are shown in Table 15. The obtained values of statistical criteria and their p-values indicate the homoscedasticity of residues and the adequacy of the constructed models.

**Table 15**

**Results of Models Evaluation**

R-squared	0.8230	0.7722	0.7536
Adjusted R-squared	0.7501	0.6784	0.6521
F-statistic	11.2949 (0.0000)	8.2338 (0.0002)	7.4280 (0.0004)
White-statistic	0.2383 (0.9694)	1.6298 (0.1938)	0.6270 (0.7273)
BPG—statistic	0.3515 (0.9178)	1.8345 (0.1452)	0.5188 (0.8082)

**Note:** p-value in parentheses ().

**Source:** evaluation of the author.

The obtained values of statistical criteria and their p-values testify the homoskedasticity of the residues and the adequacy of the constructed models.

Analyzing the impact of exogenous variables on changes of economic activity in different regions of Ukraine it becomes obvious that the initial level of regional employment is one of the main significant factors of changes in employment level as a whole in the region and in agriculture and industry in particular. Negative values of estimates coefficients  $\alpha_4$ ,  $\beta_4$ ,  $\gamma_4$  show that regions with higher initial level of employment are characterized by its lower subsequent growth and vice versa regions for which the initial employment level was lower show faster growth. Modeling shows that these trends have been observed for both sectors (agriculture and industry) and for the regional economy as a whole and point to a certain leveling during 2004–2014 of different regions in terms of percentage of employed in the total number of population. It should be noted that the coefficient of convergence for the agriculture sector is almost twice higher than the coefficient of convergence for the industry.

Index change of region integration with European countries and the CIS is a statistically significant factor of influence only for the employment level in industry and has no effect on the share of employment in agriculture. Herewith the higher is the degree of strengthening the regional industry integration with European countries the lower is the change in the share of industrial employment, while the strengthening of regional integration with the CIS countries causes a slight but statistically significant increase in the share of industrial employment in the region.

The increase in regional employment directly depends on the index of integration with the European countries before the crisis in 2008 and inversely depends on the initial index of integration with CIS countries. The detected tendency is typical for agriculture as well as for Industry and demonstrates the advantages and benefits from integration of Ukrainian regions into the European Union economy.

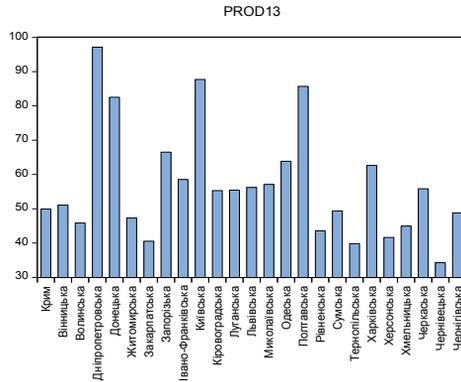
Level of employment responds differently to changes in the Theil inequality coefficient, which is a significant factor in models explaining the overall level of regional employment and share of the population employed in agriculture. Negative estimated parameter values indicate that regional diversification in Ukraine does not allow to damp down shocks inherent in each sector which are arising from the integration processes, instability and crisis phenomena but on the contrary it strengthens the impact of disturbances, particularly in the agricultural market and weaken the economy in general.

Gravity index is not a statistically significant factor of any model, therefore the geographical location of the region has no impact on the dynamic changes in the economic activity of sectors.

### **2.3. Econometric modeling of regional differences in labor productivity**

We explored also the relationship between productivity in the regions of Ukraine, uneven regional development and integration processes. Statistical data show that the highest productivity was observed in Dnipropetrovsk, Kyiv and Poltava regions

exceeding three times the values in these unproductive regions: Zakarpattia, Ternopil and Chernivtsi (Figure 18).



**Figure 18.** Labor productivity for Ukrainian regions

**Source:** data of the State Statistics Service of Ukraine, elaborations of the author

Empirical study of the relationship between productivity in the regions of Ukraine, uneven regional development and the level of integration processes we conduct based on econometric models

$$\ln PROD_{rt} = \alpha_{1t} + \alpha_{2t} E_{serv}_{rt} + \alpha_{3t} RIEI(EUR)_{rt} + \alpha_{4t} RIEI(CIS)_{rt} + \alpha_{5t} \ln GRAVITY_r + \alpha_{6t} \ln THEIL_r + \varepsilon_{rt}, \quad (14)$$

where  $PROD_{rt}$  denote labor productivity in  $r$ -th region in year  $t$ ,  $E_{serv}_{rt}$  – employment share in  $r$ -th region in service sector in year  $t$ . We estimate model parameters for two different years, namely 2008, preceding the beginning of the economic crisis, and 2015. The results of the estimation are presented in Table 15.

### The Results of Evaluation of Labor Productivity Models

Variable	Equation			
	ln <i>PROD</i> (2008)		ln <i>PROD</i> (2015)	
	Coefficient	t-Statistic	Coefficient	t-Statistic
<i>Const</i>	-8,9602	-2,231**	-16.2174	-3.894***
<i>E_serv</i>	3,3615	0,857	0.1188	3.468***
ln <i>THEIL</i>	3,0137	1,397	7.2349	3.678***
ln <i>GRAVITY</i>	0,3567	3,27***	0.3547	3.668***
<i>RIEI(EUR)</i>	-0,0028	-0,429	0.0574	3.209***
<i>RIEI(CIS)</i>	0,0318	1,841*	0.0174	3.473***
<i>R-squared</i>	0,8206		0,8264	
Adjusted <i>R-squared</i>	0,7734		0,7807	
<i>F</i> - Statistic	17,3829 (0,0000)		18,0887 (0,0000)	
White Statistic	<i>F</i> [5,19]=1,6866 (0,1862)		<i>F</i> [5,19]=0,8011 (0,5626)	
<i>BPG</i> Statistic	<i>F</i> [5,19]=1,8032 (0,1604)		<i>F</i> [5,19]=1,1278 (0,3794)	

**Note:** \*\*\*, \*\* and \* define the significancy at the level for 99%, 95% and 90% respectively, p-value in parenthesis ().

**Source:** evaluation of authors.

Analyzing the results of the model (14) evaluation we obtain the following: in 2008 productivity statistically significant only depend on the geographical location of the region, whereas in 2015 this we had the effect of economic integration indices, Theil index and uneven share of employment in services.

The estimated elasticity in productivity by Theil index found that increasing the diversification of the regional index by 1% causes productivity growth in 7.2%.

Estimated productivity elasticity according to Theil's index revealed that the increase of the regional index of employment diversification by 1% leads to an increase in labor productivity by 7.2%. The obtained result shows that the higher degree of sectoral diversification in the structure of the region's economy provides much better opportunities for redistribution of available labor resources to alternative existing and

safer types of economic activity, as a result of which the decline in certain sectors does not lead to a decline of the region's economy as a whole. In addition, the new skills acquired and the diversification of labor experience expand the capacity of entrepreneurship, especially in regions where the trafficking of workers is traced not only between different firms but also between different sectors of the economy.

GRAVITY index is a statistically significant factor of influence in both models, indicating that the geographical location has significant impact on productivity in the region. The positive and stable over time coefficient  $\alpha_5$  shows that remote (peripheral) areas have less potential for productivity growth and require to increase attention to the development and implementation of innovative regional development strategies.

Econometric analysis and modeling of changes in labor productivity in regions of Ukraine proves the significance of geographical location of the region, which is determined based on the evaluation of regional gravity index, which indicates that the geographical location of production resources significantly affects productivity in Ukraine. Modeling also proves that the increase in the indices of regional economic integration with Europe and the CIS stimulate productivity growth. However elasticities for Europe and the CIS are different and, therefore, are 5.7 and 1.7, confirming the benefits, feasibility and prospects of Ukraine's integration with the European Union.

## CONCLUSIONS

The current experience in formation and development of market Ukrainian economy demonstrates the relevance of studying regional characteristics of domestic labor sector, defining features of social and economic phenomena in the regions of our country. Based on empirical studies of the structure of regional employment by various economic activities we evaluated a number of indices, including indices regional structural change in employment (RSEC), indexes sectoral diversification of employment in each region, indices regional diversification of employment for each sector, regional indexes of economic integration (RIEI) with different groups of countries, geographic attractiveness indices of the regions. Based on the estimated indexes of the dissimilation of the employment structure (IDES), we conducted a comparative analysis of the dynamic changes in the employment level and sectoral diversification in Ukraine and several European Union countries.

As a result of analysis of employment diversification indices for different regions in Ukraine, we obtained different degree of regional specialization in sectors which, moreover, showed different trends over time. We found that among the most diversified regions of Ukraine are Kiev, Lviv, Odessa and Kharkiv regions, while the Khmelnytsky, Chernivtsi, Kherson, Luhansk and Volyn - by contrast have a high degree of specialization of employees. At the same time, none of Ukraine's regions demonstrates the level of diversification inherent in EU countries.

The analysis of the indices RSEC detected that different Ukrainian regions showed different levels of structural adjustment. Some significant changes in the structure of employment over the last decade has undergone only capital of the country, while most regions are characterized by very minor structural changes. A comparative analysis of the shares of the employed in the sectors of the economy in Ukraine and other European countries showed significant differences between them. The main difference between Ukrainian economy is significant excess of employment in agriculture and trade, low levels of employment in construction, industry, transport and communication, finance and health care. The dynamics of the indexes indicates a

deepening of the differences between the labor market structure of Ukraine and all EU countries over the past 10 years. The predominance in the structure of the distribution of Ukrainian employment in these sectors is characterized by low labor productivity, and the lack of change complicates the economic development of the regions and the country as a whole.

Based on regional data of employment structure we constructed a series of econometric models that allow us to assess the impact of the employment sectoral diversification index of the region, the index of geographic attractiveness of the region as well as the initial level of economic integration of the region with Europe and the CIS and their change over the past six years on the changes in regional employment in general, as well as in the agricultural and industrial sectors in particular. Estimation showed a certain convergence of regions in terms of share of employment in agriculture and industry. In addition, there was a significant positive impact on the change in the employment rate of the initial value of the index of economic integration with the countries of Europe and the negative impact of the integration index with the CIS countries. In particular, the results of the estimation indicated that the higher index of integration of the region with the European countries contributes to the increase of employment in this region, while the higher level of integration of the region with the CIS countries, on the contrary, worsens the situation on the regional labor market. This result, which was received both for the agricultural sector and for industry, testifies to the advantages of the European direction of economic integration of Ukraine.

The obtained modeling results also indicated that the higher degree of regional diversification in the structure of the region's economy determines significantly better opportunities for redistribution of available labor resources to alternative existing and safer types of economic activity, as a result of which the decline in some sectors does not lead to a decline of the regional economy as a whole. Also acquired new skills and work experience diversity workers extend business activity, especially in areas where movement of workers observed not only between companies but also between different sectors.

Econometric analysis and modeling of changes in labor productivity in the regions of Ukraine substantiates the statistical significance of the geographic location of the region, which is determined on the basis of the assessment of regional indexes of gravity, which suggests that the geographical location of productive resources has a significant impact on labor productivity in Ukraine. An effective and stable time value of the coefficient reveals that remote (peripheral) regions have less potential for increasing labor productivity and need to increase attention to the development and implementation of an innovative regional development strategy. The modeling also justifies that the increase of indices of regional economic integration with the countries of Europe and the CIS countries stimulates the growth of labor productivity. However, the coefficients of elasticity for the countries of Europe and the CIS differ and, accordingly, take values 5.7 and 1.7, which testifies the advantages, expediency and prospects of Ukraine's integration with the European Union.

Consequently, the results of the analysis indicate the need for structural changes and reform of the infrastructure of regional labor markets; increasing attention to the development of human capital and education sector in the industrial regions of the country; directing the measures of the economic policy of the state to increase the incomes of the population, which, given the revealed reaction of consumption, would lead to a significant increase in demand and due to high values of the multipliers would have a positive impact on GDP and employment, as well as the European direction of integration processes and public administration in Ukraine which as evidenced by the results of estimation will stimulate positive processes of development of the national labor market.

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