The Innovation Development in Ukraine: Problems and Development Perspectives

The paper explores the economical approaches in innovation development in Ukraine. The application of hierarchical cluster analysis for 27 Ukrainian regions in 2001 to 2005 confirms the low convergence between three clusters. The sufficient industrial and scientific endowment inheritance creates opportunities to exploit potentials and to improve position in cluster 2. The research strengthens the dependence of regional cluster classification on the input factors of production combination in Ukrainian regions. Our results anticipate that the special regional policy measures may be the effective approach for regional inequalities reduction, innovation development, and the economic growth stimulation.

Keywords: innovation, development, convergence, divergence, hierarchical cluster analysis.

1. Introduction

The emergence of a global knowledge economy requires a radical transformation of innovation strategy in East European countries. Innovation is regarded as a basic driving force in the process of narrowing gaps with developing countries in global economy. Innovation is considered as important precondition towards a transition into self-sustaining innovation led- growth economy. Effective innovation system includes firms, research centers, R&D institutions which provide new goods creation, new processes and new knowledge.

The concepts of technological accumulation and creative destruction are the core of J. Schumpeterian theory. The author emphasizes the distinctness of R&D from other investments in physical or human capital. The Schumpeter's approach provides a detailed account of the economic and institutional determinants of long-run growth; and to conceive of the possibility that growth be made sustainable in an economy with limited natural input resources.

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The aim of paper is devoted to the analysis of the impact of innovations on convergence (divergence) in the Ukraine. The main goal is the definition of the causes of regional disparities', and estimation of the role of innovation activity for regional inequalities smoothing. The hierarchical cluster analysis for 27 Ukraine's regions is applied for identification strong and weak regions, and explaining innovation policy.

David and Foray (2004) argue that innovative capacity is related to great extent to the ability to both systematically combine and make new uses of existing knowledge, rather than discovering new technological principles. Thus it is not the development of new knowledge that plays a significant role in the economic processes but its combination and reorganization. Trippl and Maier (2010) identify a set of mechanisms by which star scientists may influence the innovation dynamics of their regions. These included connections to the regional academic world (academic collaborations and provisions of talent for the scientific labour market) and to the policy world (advice of policy makers) as well as differentiated typology of models of knowledge sharing with the industrial world.

Reutov (2007) estimates the competitiveness of international regional economic systems on the

basis of parameters, technique of calculation, and suggests the uniform integrated parameter of competitiveness of region. Polyakova, Babez (2006) examine the main tendencies of regional innovation systems formation and conducted the cluster analysis of Ukrainian regions in 2003. They use the following basic variables: total volume of innovation costs per one thousand employed; internal current R&D costs; the number of applied patents; the number of people involved in R&D; and the number of enterprises used innovations. The authors classify regions in 4 groups: the highest innovation activity; the high innovation activity; the average innovation activity, and the low innovation activity.

The Ukraine's regional economic performance assessment includes the estimation of the significant factors influencing the existence of disproportions between the sectors. The basic problems of regional development relate to the lack of capital investments, old capital assets, and high share of unprofitable enterprises, enterprise's indebtedness, low level of innovations, and insufficient infrastructure level in Ukraine.

The assessment of Ukrainian competitiveness shows the markets concentration at national level and inadequate finance and human capital distribution in regions. The competition is still weaker at regional level. Concentration has a negative and highly significant effect on labor productivity growth. The financial shortage causes the reduction of the quantity of enterprises applied the innovations. The specific weight of such enterprises decreases from 18 percent in 2000 to 13 percent in 2008. The negative trend in financing innovation activities was strengthened under the impact of world financial crisis. Bukin (2011) points out that the state didn't play a significant role in financing innovation activity during the last years, where its' share exceeded 1.7 percent in 2009.

The level of innovative spending shrunk from the maximum spending 48.8 percent in fixed prices in 2007 by 26 percent and 5 percent in current prices in 2009. The companies' own

funds are considered to be the most important source in financing innovation activities. In the period of the crisis spending has decreased by 29.3 percent in 2008 and by 56.5 percent in 2009 in comparison with the 2007 level. The share of bank loans as important source for innovative spending has grown from 6 percent in 2000 to almost one third of total spending in 2008. One can mention the period of a credit boom in the Ukraine with lending increase from 8 percent in 2006 to 33 percent in 2008. But due to the impact of the world financial crisis the share of credit was shrinking in Ukraine with the outbreak of and also reforms in the banking sector. The share of foreign capital financing innovations rose sharply from 1 percent in 2008 to 19 percent in 2009. The national investors' share dropped down to the level of 0.4 percent in 2009 (InnoPolicy, 2011).

The study of empirical results of convergence (divergence) shows that it isn't adequately explained by the neoclassical model. The most of the literature on the convergence (divergence) is based on the analysis of cross-sectional averages or starting values for time-series data. The use of this approach does not provide the estimation of unobserved regional specific differences, and does not account the important changes during the period of time.

2. The Ukrainian Economic Performance

The crisis of 2008-2009 significantly affects the economic development in the Eastern European countries. Global growth dropped to almost 3 percent in 2012, which indicates that about a half a percentage point has been shaved off the long-term trend since the crisis emerged.[1] The global financial crisis drop in GDP is about 4 percent and at least Latvia and Ukraine are likely to face double - digit decline.[2] The fixed exchange rate evokes the speculative motives for short-term lending from European banks, and results in increase the balance of payments deficits in East

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[1] See Global Economic Outlook (2013).
[2] See Aslund (2009), p.2.

Europe. The slowing global trend stipulates the rise of inequalities and imbalances within Ukraine. The number of depressed regions increases, and as a result regional disparities are accumulated. GDP showed a positive dynamic starting from 2000 until 2009 when the GDP dropped by 15.1 percent which was a direct consequence of the world financial crisis (Table 1). Inflation in Ukraine remains relatively high (10-20 percent increase annually with the lowest level in 2002 (0.7 percent) and the highest ones in 2000 (28.2 percent) and 2008 (25.2 percent). The value of the current account balance had a surplus during 1999-2005 period with the highest value in 2004 (6.9 billion US dollars) and a deficit during 2006-2009 with the lowest value in 2008 (12.8 billion US dollars).

Table 1: Gross Domestic Product in Ukraine (percentage change in real terms)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GDP	5.9	9.2	5.2	9.6	12.1	2.7	7.3	7.9	2.1	-15.1	4

Source: European Bank for Reconstruction and Development, online database
www.ebrd.com (accessed on September 07, 2011)

The analysis of Ukrainian macroeconomic data in 2012 depicts on the tendency of industrial production shortage in heavy industry, including metallurgy and coal-mining industry. It explains through the high production costs, inefficient labor organization, and undeveloped infrastructure. The analysis of economic assessment of Ukrainian competitiveness in 2012 shows the market concentration at national level and the high degree between regional markets. The competition is still weaker at regional level. Concentration has a negative and highly significant effect on labor productivity growth[3].

Table 2: Competitiveness of Ukraine's regions

Rank	Country/ Economy/ Region	Score	Rank	Country/ Economy/ Region	Score
52	Croatia	4,25	74	**Donetsk**	4,07
53	**Kyiv**	**4,25**	75	**Ukraine**	4,07
54	**Dnepropetrovsk**	**4,24**	76	Botswana	**4,07**
55	Cyprus	4,23	77	Egypt	**4,06**
56	Kazakhstan	4,23	78	**Poltava**	4,02
57	**Zakarpattia**	**4,22**	79	Philippines	**4,02**
58	EL Salvador	4,20	80	Romania	**4,00**
62	Russian Federation	4,14	81	**Crimea**	3,99
63	**Lvov**	4,14	82	**Vinnitsa**	3,98
64	Jamaica	4,14	83	Argentina	**3,98**
68	Costa Rica	4,10	90	Uruguay	**3,91**
69	**Khmelnitsky**	4,10	91	**Kherson**	3,90
70	Brazil	4,10	92	Bosnia and Herzegovina	**3,86**
72	Vietnam	4,08	93	**Cherkassy**	3,85
73	Sumy	**4,07**	**94**	**Armenia**	**3,82**

[3] See OECD (2007), p. 2.

The regional competitiveness estimation of 12 Ukraine's regions based on the methodology of Global Competitiveness Index (GCI) examines that Kyiv, Dnepropetrovsk, Sumy, Donetsk, These indicators demonstrate the low labor productivity per capita in the Ukraine comparing to world competitiveness estimation in 55 countries. Shehovzeva (2007) outlines the use of the regional competitiveness index. It combines the regional labor and capital assessment. Gross regional product (GRP) per capita is the most significant index characterizing the regional potential for producing goods and services. [4]

Lvov are ranked on the first tier of regions between Croatia and behind Vietnam in 2005. The second tier of regions includes Poltava, Crimea and Vinnitsa regions. It takes positions below Ukrainian average but ahead of Argentina. The third group Kherson and Cherkassy occupies a very low position between Uruguay and behind Bosnia and Herzegovina (Table 2). [5] The scores of the best and worst performing regions make up 5 percent above or below the national average. The estimation results point out the lower level divergence in terms of GRP per capita. Hanouz, Geiger, Panov (2008) make a conclusion that the degree of economic divergence between Ukrainian regions is moderate comparing to other countries.[6]

The deteriorated domestic and external demand affects the output decrease in the major sectors of Ukrainian economy. The volume of industrial production, fixed capital investment, exports and imports of goods and services have decreasing tendency. The consumer price index is increased. The current account and financial account deficit is covered by the interventions of the National Bank of Ukraine.

3. Econometric Modeling

To investigate economic perspectives of convergence (divergence) of regional development, we apply hierarchical cluster analysis and estimate the basic parameters in Ukrainian regions. The choice of selected model variables is based on the standard Cobb - Douglas production function use, where

$Y = A \cdot K^{£} \cdot L^{\beta}$, (1) where Y – total production;

L – labor unit;

K – capital unit;

A – total factor productivity;

£, β – the constant elasticities of labor and capital.

The production function specification is used for explanation of the minimum input requirements for production designated quantities of output on the basis of available technology. The parameters selection for cluster analysis is based on the application of Cobb - Douglas production function.

We assume that Gross Regional Product (GRP) is associated with total production in the region. The employment defines labor in the region. Industrial production index and fixed capital investment index determine regional capital. The number of organizations, conducting scientific research, total value of innovation costs per one thousand employed workers and foreign direct investment in region denote total factor productivity. We use annual data of economic performance from 2001 to 2005 for 27 Ukrainian

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[4] See Shehovzeva (2000), p.32.
[5] See Hanouz, Geiger, Panov (2008), p. 101.
[6] See Ibid, p. 104.

regions. In detail the following variables are available and are considered where index i runs over all 27 regions, and index t over all time periods considered (years).[7]

$GRP_{it} = F(IPI_{it}, FCII_{it}, EMP_{it}, FDI_{it}, NIO_{it}, TVCI_{it})$, (2) where GRP_{it} – Real Gross Regional Product per Capita (UAH);

IPI_{it} – Industrial Production Index, where 2000 = 100% (%);

$FCII_{it}$ –Fixed Capital Investment Index (percentage from the previous year);

FDI_{it} – Foreign Direct Investment per Capita in Real Prices (UAH);

EMP_{it} – Employment of Working People from 17 to 70 Years (thousand people);

NIO_{it} - Number of Organizations, Conducting Scientific Research;

$TVCI_{it}$ – Total Value of Innovation Costs per one Thousand Employees (%).

We apply industrial production index, fixed capital investment index, foreign direct investment per capita, employment, number of organizations, conducting scientific research, total value of innovation costs in the hierarchical cluster analysis for 27 Ukrainian regions in 2001 to 2005. The indicated period of time has been chosen due to the full set of data. We test the following hypothesis: the dependence of regional cluster classification on the input factors of production combination in regions.

We assess calculating distances between the most developed regions and the undeveloped regions in hierarchical clustering. We estimate the single linkage criteria, showing the distance between the closest neighboring points. The estimation results outline that the Kyiv region is distinguished from other regions. Capital Kyiv is considered to be outlier from other Ukrainian regions for all estimated periods of time.

The strong specialization by regions producing specific kinds of heavy industry products caused

to the division between highly industrialized developed regions with high urbanization and backward rural regions with agrarian orientation in the Ukraine. The centralized industrial organization and the inefficient regional structure formation resulted in the disproportionate regional division in the former Soviet Union.

The present structure does not take into account the geographical location, the economic endowment, and regional specificity. The application Ward's method calculates the simple Euclidean distances from each case in a cluster to the mean of all variables. The graphical analysis of the line of the significant coefficients Ward's method proves the basic three clusters determination. The three clusters differ in particular in regard to the levels of industrial development and scientific potential. One could mention the increase of heterogeneity with every step of econometric analysis. A hierarchical clustering model of 27 regions is graphically represented at the dendogram. Each region has various distributions. It is evident that the first cluster includes the cities of Kyiv, Kharkov, Dnepropetrovsk and Donetsk (Fig. 1).

The first cluster shows relatively higher than average level of economic estimation in comparison with two others. It distinguishes via the biggest industrial production concentration, the attraction of the significant financial flows of capital, the highest innovation capacity within regions, and more than average per capita income in comparison to Ukraine. The capital Kiev inclusion from the cluster 1 demonstrates the estimation results for 2004. Within this period there was the structural break, which could be seen in the given assessment. The business activity decrease, macroeconomic instability and insufficient quality of institutions constitute a major impediment to Ukraine's regional economic performance as reflected in the regional indicators for 2004. The regional content of the cluster 2 and the cluster 3 are shown as unstable and changeable for all estimation periods (Fig. 1, 2).

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[7] The data for 2001 – 2005 see Regional Statistical Surveys Ukraine in 2006. State Statistical Committee in the Ukraine, http//www.ukrstat.gov.ua

Dendrogramm verwendet Durchschnittliche Linkage (Zwischen den Gruppen)

Kombination skalierter Abstands-Cluster
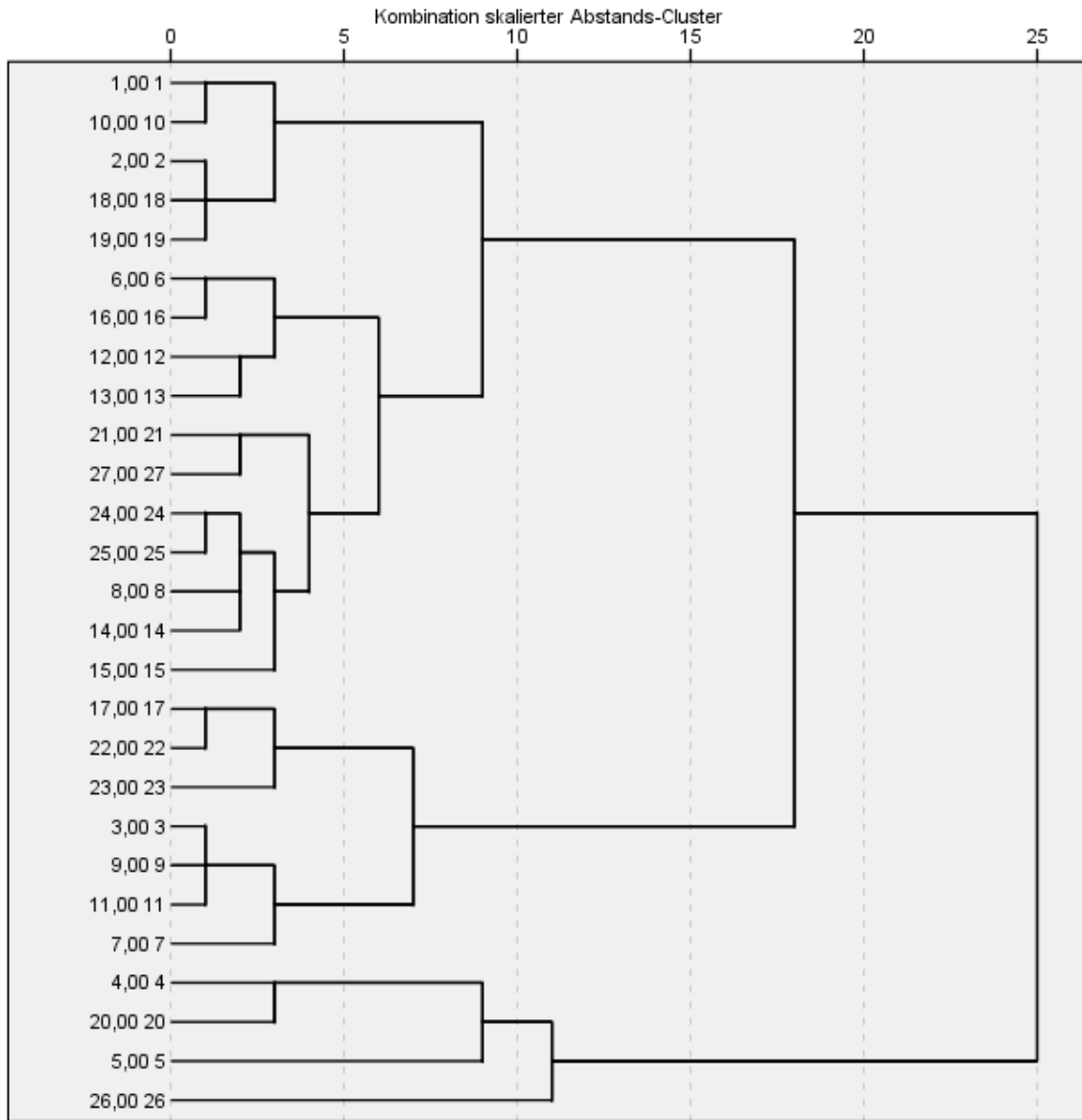
The industrial, scientific potential of these regions are significantly low in comparison to the cluster 1. The cluster 2 and cluster 3 include some regions, which are specialized in agrarian production. The cluster mobility shows the low spread in economic development between regions.

Fig. 1: DendogramWard's Method 2005

The typical features for all clusters combine insufficient tax regulation (the highest tax rate of 60. 3 percent in the world), and inadequate investment due to saving rate decline. The region transference between clusters could be explained by regional policy inconsistency. Some regions with average industrial potential move to the cluster 3. The industrial production reduction

and low labor productivity in basic sectors of economy make worse the regional differences. In sum results suggest that there could be seen the dependence between all three regional clusters classification on the input factors of production combination in regions. It is important to mention that there are substantial differences between the cluster 1 and the clusters 2, 3, which strengthens the significant difference between the industrially developed regions and average developed regions, backward regions. The estimation confirms the low convergence between the first and the second, the third clusters. The relationship between main economic indicators of economic development of average developed and backward regions demonstrates less heterogeneity and more homogeneity.

In order to receive the consistent results on the regions' list of average developed and backward regions we exclude the first cluster from hierarchical cluster analysis. The estimation results could be seen in Fig. 2. The Ward's method estimation proves the division between cluster 2 and cluster 3. The assessment results shows less heterogeneity between regions with every step of the hierarchical cluster analysis. The main regions Autonomous Republic Crimea, Zaporozhe, Kievskaya, Lvov, Odessa, Luhansk, and Nikolayev appear in all tests and form the cluster 2. This cluster includes regions with average industrial and scientific potential. The rest regions form the cluster 3 with lower than average development capacities. Some agrarian regions perform below the country's average cluster 3. The cultural and geographical differences, insufficient endowments of crucial productive factors reflect the peculiarities of weak structural development. The table 1 presents the cluster classification of Ukrainian regions based on the main economic indicators in 2001 – 2005. The cluster 1 includes four regions with high industrial and scientific potential. Kiev, Kharkov, Dnepropetrovsk and Donetsk regions show the best performing capital, labor, R&D capacities in the country. The fixed capital investment per capita in Kiev

region is equaled to 1585 uah in the first quarter of 2009. Its value is the biggest in comparison with other regions. The bulk of all foreign capital is concentrated in the capital. FDI per capita makes up 5176 US dollars at the same period. The Kiev region has the highest capital accumulation and per capita income distribution in comparison to other regions.

Regions with lower industrial production index, fixed capital investment index, FDI inflow per capita, and small investment in R&D form cluster 2. The regions with low industrial potential make up cluster 3. These regions are traditionally specialized in agrarian production. The allocation of resources and structure of production anticipate the backwardness of these regions. Agricultural subsidies amount makes up 1.1 billion US dollars in direct support, and 0.65 billion US dollars in tax exemptions.[8] The absence of significant structural changes reflects serious problems existence in agricultural sector. The moratorium on the selling of agricultural land constitutes the impediment for market relations development. Labor market imperfection work evokes low labor productivity in the agrarian sector. The labor relationship between employer and employee does not create incentives for the best use of available talent in agricultural production and limits production modernization.

The hierarchal cluster analysis reflects the spread in the performance between regions and the need of the specific factors impacts assessment. The longer estimation period of research should be taken in consideration for ongoing statistical analysis. The comparison of gross value added per capita marks the significant difference between the industrialized region in the cluster 1 and the others clusters. The disparity of gross value added per capita of the city of Kiev is more than six times the lowest Chernovtsy region (Fig. 2).

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[8] See World Population Prospects (2006).

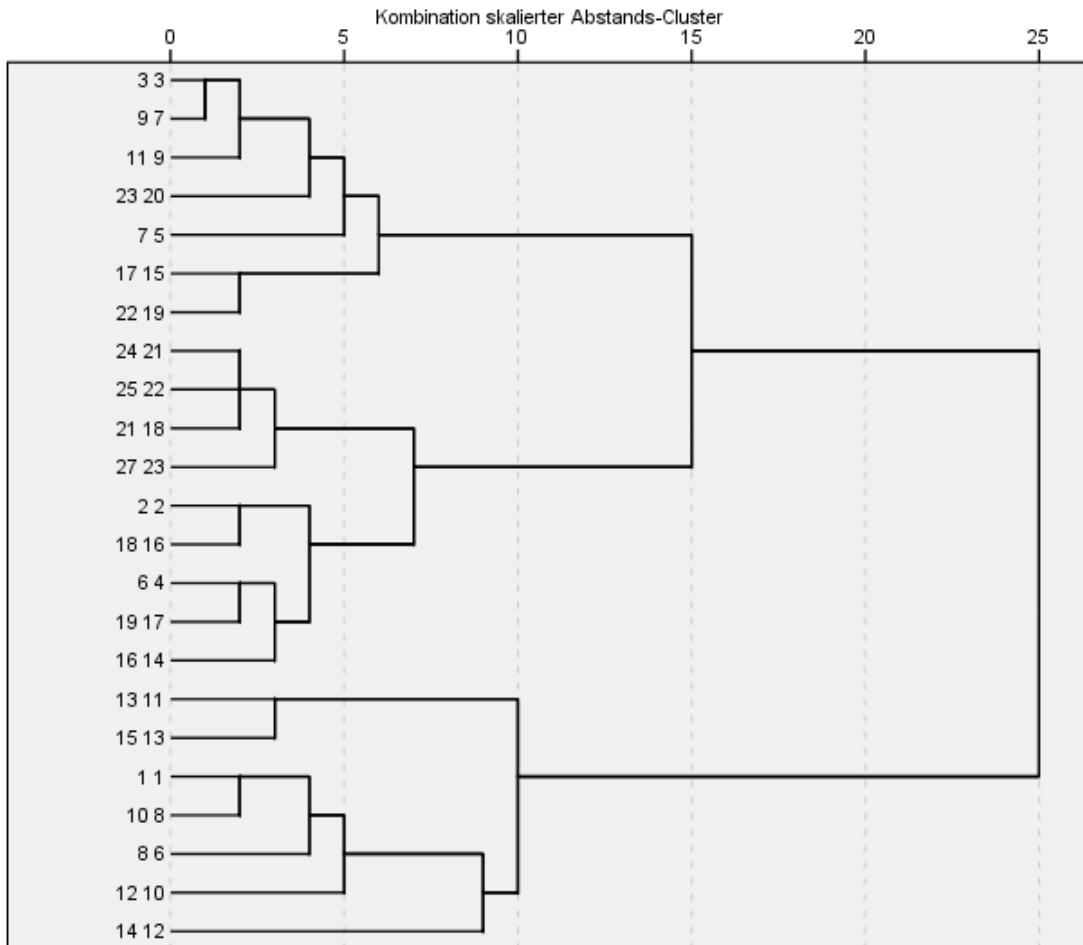## Dendrogramm verwendet Durchschnittliche Linkage (Zwischen den Gruppen)

Fig.2: Dendogram Ward Method 2005 (without developed regions)

The assessment of gross regional product per capita in Kiev exceeds three times Ukraine's average in 2005. The lowest gross regional product per capita is estimated in cluster 3, including Chernovtsy, Ternopol, Zakarpattia, Zhitomir, Vinnitsa, Khmelnitsky, Kherson regions (Table 3). The State Statistics Committee of Ukraine assesses the negative real growth rate in Donetsk, Zakarpattia, Lvov, Odessa, Poltava, Kherson regions in 2005. The fixed capital investment distribution reflects the tendency of capital concentration in the regions belonging to cluster 1. The difference of the share of enterprises conducting innovations in the total volume of industrial enterprises of the city Kiev is ten times more than in the lowest indicator in Rovno in 2005 (Table 4). The estimation data of gross regional product per capita, fixed capital investment, FDI, the share of enterprises conducting innovations proves that Kievskaya, Odessa, Nikolayev, Poltava regions have sufficient industrial and innovation potential to improve their position and to move to cluster 1.

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Table 3: The cluster classification of Ukrainian Regions based on the main economic indicators in 2001 – 2005

№ Cluster	Regions of the Cluster	The Title of the Cluster
I	Kiev (26) Kharkov (20) Dnepropetrovsk (4) Donetsk (5)	**High industrial and scientific potential**
II	Autonomous Republic Crimea (1) Zaporozhe (8) Kievskaya (10) Lvov (13) Odessa (15) Lugansk (12) Nikolayev (14)	**Average scientific and industrial potential**
III	**Vinnitsa (2) Volyn (3 Zhitomir (6) Zakarpattia (7) Ivano-Frankovsk (9) Kirovograd (11) Poltava (16) Rovno (17) Sumy (18) Ternopol (19) Kherson (21) Khmelnitsky (22) Cherkassy (23) Chernovtsy (24) Chernigov (25) The city of Sevastopol (27)**	**Low scientific and industrial potential**

Fig.3: The Gross Value Added per Capita in Ukrainian regions (in real prices, uah)
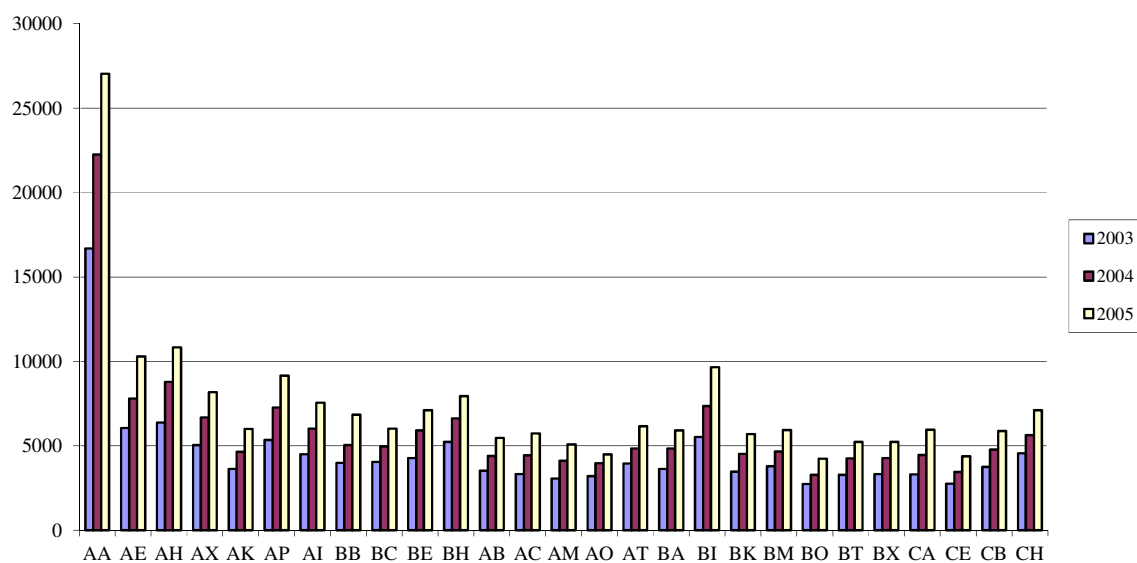
Source: Data of the State Statistic Committee in Ukraine in 2003 - 2005.

Table 4: The Regional Economic Performance in 2005

N cluster	Regions of the cluster	GRP per capita (uah)	Fixed capital investment per capita (uah)	Foreign direct investment (USD)	The share of enterprises conducting innovations
1	Kiev city	28780	7379	2861	**40**
1	Kharkov	9025	2045	388	**18**
1	Dnepropetrovsk	11909	2253	821	**13**
1	Donetsk	12490	2071	530	**10**
2	Autonomous Republic of Crimea	6460	1704	331	**14**
2	Zaporozhe	10683	1766	486	**9**
2	Kievskaya	8673	2560	522	**10**
2	Lvov	6657	1826	358	**6**
2	Odessa	8619	2149	517	**13**
2	Luhansk	8131	1803	146	**6**
2	Nikolayev	7801	2071	75	**10**
3	Vinnitsa	5966	994	66	**9**
3	Violin	6285	1140	97	**9**
3	Zhitomir	5554	848	82	**12**
3	Zakarpattia	5373	896	244	**10**
3	Ivano-Frankovsk	6916	1212	121	**13**
3	Kirovograd	6394	1202	107	**14**
3	Poltava	11574	2384	210	**10**
3	River	6269	1023	71	**4**
3	Sumy	6497	1169	135	**4**
3	Ternopol	4603	800	37	**11**
3	Kherson	5713	953	75	**11**
3	Khmelnitsky	5764	1061	66	**6**
3	Cherkassy	6681	1521	122	**9**
3	Chernovtsy	4654	832	24	**13**
3	Chernigov	6474	1139	96	**9**
3	**Sevastopol city**	**7452**	**1445**	**67**	**8**

The ascription of all regions to the particular cluster depends on the overall estimation of all parameters in the period from 2001 - 2005. The division into three clusters highlights the significant factors estimation influencing the existence of disproportions between the regions. The regional policy for regions in cluster 3 have to be concentrated on promotion the growth of backward regions through subsidies, tax allowances, and foreign capital attraction. The research results emphasize the existence of the dependence of regional cluster classification on the input factors of production combination in regions.

The hierarchal cluster analysis reflects the spread in the performance between regions and the need of the specific factors assessment. The longer estimation period of research should be taken in consideration for ongoing statistical analysis. The comparison of gross value added per capita marks the significant difference between the industrialized region in the cluster 1 and the

others clusters. The sufficient industrial and scientific endowment inheritance creates opportunities to exploit potentials, and to improve position in cluster 2. The regional policy for regions in cluster 3 have to be concentrated on promotion the growth of backward regions through subsidies, tax allowances, and foreign capital attraction. The research strengthens the dependence of regional cluster classification on the input factors of production combination, promoting activities in innovation development at a regional level. The estimation of weak and strong regions explains the tendency for convergence or divergence. The regional policy identification is suggested to discover the measures for inequality reduction, regional attractiveness increase, and economic growth stimulation. The regional imbalances cause the need for redistribution mechanism foundation into financing the development of depressed regions with low income per capita. The fiscal equalization could be provided until these regions could reach the level of fixed minimum income per capita. The determination of the regions, which are oriented on priority innovation development, will be directed to stimulate economic growth and smooth the regional inequalities and disparities.

4. Policy Options for Regional Development

The research strengthens the dependence of regional cluster classification on the input factors of production combination in Ukrainian regions. The application of hierarchical cluster analysis for 27 Ukrainian regions for 2001 to 2005 confirms the low convergence between the first and the second, the third clusters. The difference between the main economic indicators of economic development of average developed and backward regions demonstrates less heterogeneity and more homogeneity. The sufficient industrial and scientific endowment inheritance creates opportunities to exploit potentials and improvement countries position in cluster 2.

Our results suggest that the special regional policy measures may be the effective for regional inequalities reduction, and the economic growth stimulation. Efficient allocation of resources aims the adoption of micro and macro economic measures for labor productivity per capita increase, concentration of production growth, entrepreneurship development; and the regions' competitiveness positions improvement. The spillover effect, reduction of regional productivity differentials, and labor efficiency rise are stimulated by foreign capital inflow and labor force education and training. Lasting a long time regional growth could be achieved on the basis of elaboration and application of innovations in all sectors of production in regions.

The regional policy determination considers the regional disparities elimination and suggestion of the scenarios for smoothing regional inequalities. We consider the following basic tasks for sustainable regional development:

- The regional economic structure improvement on the basis of the production structure diversification in the regions, including the predominance of several specific sectors of economy;

- The state and business resources concentration in the sphere of advanced new technologies;

- The interregional competition intensification, and, as a result, regional competitiveness of products and services increase to the average level in backward regions;

- The regional economic independence increase in decision making process for basic economic and social tasks solution.

The state should provide the tax regulation policy, limited subsidies, and tax allowances. The regional integration intensification could be achieved via income redistribution between strong regions in favor of weak regions. The infrastructure developments, investment in education, job training and retraining programs have significant impact on social performance.

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5. Conclusions

The main directions of regional development could be determined in accordance with regions' belongings to the special cluster group. The following policy measures could be proposed for three groups of clusters:

- to provide the top-priority investment in R&D and in education, informational network improvement in cluster 1, which could become a locomotive for future regional innovation development;

- to increase per capita income to the average level in regions through the diversification of the production structure, subsidies elimination, unprofitable state enterprises close, human capital investment, infrastructure development in cluster 2;

- to increase fixed capital investment, education improvement, subsidies, tax allowances to backward regions until they reach the average minimum per capita in cluster 3.

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