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Post-communist financial and economic development: cluster analysis of selected countries

Abstract
Purpose. The purpose of this paper is to disclose and explain disparities of social and economic development of twenty-eight post-communist countries based on the World Bank's macroeconomic indicators of the selected countries in 2000-2014. The paper questions whether post-communist countries are homogeneous within certain groupings and essentially different across different groupings. The differences are defined in accordance with World Development Indicators.
Methods. We have applied cluster analysis to classify post-communist countries based on the long-term average of macroeconomic indicators including: GDP per capita, GDP per capita growth, Foreign direct investment net inflows (percentage of GDP), Agriculture value added (percentage of GDP), Industry value added (percentage of GDP), Total natural resources rents (percentage of GDP), and Value added (percentage of GDP), etc. The Kruskal-Wallis rank test procedure has been used to verify differences between clusters of evidence.
Results. Taking into consideration the results obtained via Ward's method we divided post-communist countries into three relatively homogeneous clusters. Cluster 1 consisted of Armenia, Azerbaijan, Georgia, Kyrgyz Republic, Moldova, Mongolia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan although Azerbaijan and Turkmenistan were assigned to Cluster 2 in the period of 2010-2014. Cluster 2 included Albania, Belarus, Bulgaria, Kazakhstan, FYR of Macedonia, Romania, the Russian Federation, Serbia, Bosnia and Herzegovina. The third cluster comprised Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland and Slovak Republic. The Kruskal-Wallis rank test indicates statistically significant cluster differences (0.05 level of significance) for GDP per capita, GDP per capita growth, Inflation GDP deflator, Agriculture value added, Total natural resources rents, Services etc. value added. The only exception is GDP per capita growth, which has not been significantly different in 2000-2004. The conclusions are based on p-values, which have been compared with values appropriate to the level of significance ($\alpha = 0.05$).
Conclusions Although all countries in our research were post-communist countries, their economic trajectory after communism was far from being identical. We have found fairly consistent evidence that post-communist countries differ with respect to their social and economic dynamics and can be grouped into three relatively homogeneous clusters.
Keywords: Cluster Analysis; Post-communist Countries; Macroeconomic Indicators; Economic Development; Social and Economic Discrepancies
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Посткомуністичний фінансово-економічний розвиток: кластер ний аналіз окремих країн
Анотація. Досліджено розподіл окремих посткомуністичних країн по групах на основі кластерного аналізу макроекономічних показників. Проаналізовано сучасні тенденції соціально-економічного розвитку в межах зазначених кластерів. Проведено порівняння макроекономічної динаміки між виявленими однорідними групами країн.
Ключові слова: кластерний аналіз; посткомуністичні країни; макроекономічні індикатори; економічний розвиток; соціально-економічні відмінності.

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Аннотация. Исследовано распределение избранных посткоммунистических стран по группам на основе кластерного анализа макроэкономических показателей. Проанализированы современные тенденции социально-экономического развития в рамках указанных кластеров. Проведено сравнение макроэкономической динамики между выявленными однородными группами стран.
Ключевые слова: кластерный анализ; посткоммунистические страны; макроэкономические индикаторы; экономическое развитие; социально-экономические различия.

1. Introduction

The purpose of our research is to identify and explain disparities of social and economic development of 28 post-communist countries based on 15 years of World Bank macroeconomic indicators for the selected countries from 2000 to 2014. There are two main reasons for the above-mentioned time frame. Firstly, the availability of comparable and relevant statistical data. Secondly, the necessary and sufficient time lag of approximately a decade (after the collapse of communism) for common and distinct features to emerge. Our research raises a question whether post-communist countries are homogeneous by group identification of similarity and essentially different countries in accordance with World Development Indicators.

2. Brief Literature Review

There exists a considerable body of literature on post-communist countries. For instance, T. Domonkos and F. Ostrihon discovered that the selected countries (including the Czech Republic, Hungary, Poland, and the Slovak Republic) experienced positive economic growth accompanied by absolute pro-poor growth throughout 2006-2012, but in only few time periods, and not for all of the poverty measures applied [4, 881].

K. Czarnecki argues that no regular pattern of policy related to higher education has been found amongst the four «post-communist» countries belonging to the Visegrad Group [3, 60]. Thus, as far as this policy is concerned as part of welfare policies, one cannot identify the existence of a distinct «post-communist» welfare regime.

M. Grancay, E. Sumilo and J. Vveinhardt show that since the EU's Eastern enlargement of 2004, trade patterns within the European Union have converged [6, 458]. The convergence includes exports and imports per capita as well as productivity levels associated with the member states' export baskets. Post-communist countries also faced the convergence of per capita trade volumes and productivity levels of export baskets accompanied by economic growth.

H. F. Zeaiter, R. El Khalil and K. Fakih determine that the explanatory variables of economic growth in Eastern Europe are less responsive to the per capita income with the mortality rate and the FDI being the only significant variables, which could be explained by their communist past [16, 167].

L. Tamilina and N. Tamilina explain the impact of peculiarities of institutional effects on growth rates in post-communist countries by proposing a certain dependence of the institution growth nexus on the nature of institutional emergence and introducing a distinction between revolutionary and evolutionary processes of the formation of institutions [11, 205].

E. Bah and J. C. Brada illustrate the heterogeneity of national experiences of the development of labour market in transition countries [2, 45]. While experiencing a significant unemployment at the onset of transition and during the recent crisis, the Central European and Baltic countries have by now established functioning labour markets. Economic recovery from the transition recession in Balkan and post-Soviet countries has been much less dynamic, have continued to yield many low-paying jobs without great prospects for long-term improvement, and resulted in a business climate less conducive to the creation of new jobs.

N. Hiekel, A. C. Liefbroer, A. Poortman shed a light on economic reasons and differences of cohabitation perception across Western and Eastern Europe [7, 391]. Their study proves that cohabitation as an alternative to marriage is more prevalent in Western and Northern Europe, while Central and Eastern Europeans (including post-communist countries) tend to view it as a temporary stage before marriage.

F. Roosma, J. Gelissen, and W. Oorschot, suggest that attitudes towards the dimensions differ between Western/Northern and Eastern/Southern European welfare states [9, 250]. In Western/Northern European countries, respondents are more positive towards the outcomes and efficiency of the welfare state than in Eastern/Southern European countries. In the latter, respondents combine a positive attitude towards the role and goals of the government with a more critical attitude towards the state's efficiency relevant to welfare and intended outcomes. This is because of their unique mostly post-communist transition (regarding the Eastern European countries).

P. Abbott and C. Wallace determine that improving economic performance will not increase the quality of society in post-communist countries unless there is also a decline in income inequality and improvements are reflected in the ability of households to manage their economic well-being [1, 435]. A general improvement in GDP per capita does not necessarily translate directly into better well-being for households as the social and economic structure of the society must be taken into account.

H. Wagner provides an overview of the empirical evidence of real convergence within the European integration process (involving post-communist countries) and highlights the fact that the lack of ex ante institutional convergence has induced or aggravated the debt crisis in the Eurozone as soon as a large financial shock hit the Union [12, 196].

C. C. Williams and I. A. Horodnic explain the prevalence of the shadow economy by the impact of tax morale [13, 93]. The authors argue that the lower the tax morale is (Estonia, Latvia, Lithuania and Poland), the more likely is the participation in the shadow economy (i.e. paid activities not declared to the authorities for tax, social security and/or labour law purposes).

L. Holmes states that some countries (Estonia, Slovenia and other Central European countries) consistently emerge as the least corrupt post-communist states, whereas others, notably Central Asian states, Russia, and Ukraine,regularly appear to be among the most corrupt [8, 1181]. Whether this relates primarily to standards of living, institutional arrangements, communist or pre-communist traditions, or other variables is difficult to determine.

V. Yarashevich argues that increased demand for local manufactured goods should translate into more blue-collar jobs and better social security for the workers of Belarus, Kazakhstan, and Russia [15, 616]. On the political side, though, this may play in the hands of increasingly authoritarian political regimes.

In spite of continuous scientific discussion of different aspects of post-communist development, additional attention should be paid to cluster analysis of financial and economic indicators of post-communist countries all over the world.

3. The purpose of our research is to provide an overview of issues related to disparities in social and economic development for 28 post-communist countries. Our analysis is based on the World Bank's macroeconomic indicators of the 28 countries from the year 2000 until the year 2014.

Data and Methods. Cluster analysis is a multivariate statistical technique that divides a large group of observations into smaller, relatively homogeneous groups. The source of our data is the World Bank's database. A detailed description of the indicator can be found on the webpage stated in reference list [14]. The data were averaged across five years in three reference periods: 2000-2004, 2005-2009 and 2010-2014 in order to mitigate specific effects in particular years. Our aim is to identify a group of countries which are similar to each other but different from other groups of countries based on the studied characteristics. We selected and applied Ward's method for clustering. Ward's method is an agglomerative hierarchical clustering procedure. Based on the least-squares criteria, it minimises the within-cluster sum of squares, thus maximising the within-cluster homogeneity [5]. At the first stage of clustering, each statistical object is considered an individual cluster and, subsequently, objects are grouped to superior clusters which are again grouped with regard to the distance between them, while the objects with the smallest distance between are grouped together. After the highest level of clustering, all statistical objects are joined into one cluster. To measure the distance between the objects the metric of Euclidian distance was used:

$$d(p,q) = \sqrt{\sum_{i=1}^{k} (q_i - p_i)^2} \quad (1)$$

where k represents the number of statistical characteristics observed on subjects, and pi and qi are two k-dimensional data objects.

The process of Ward's method is an iterative process repeated until each of all the clusters is formed into a single massive cluster. Cluster analysis was performed in Stata [10], by applying Ward's linkage. The same clustering procedure was applied to analyse data in the period of 2000-2004, 2005-2009 and 2010-2014.

4. Results

In this section, we present and discuss the results of the clusters obtained from the Ward Method of clustering (Figures 1, 2 and 3), then the significant differences among the clusters from the Kruskal-Wallis rank test procedure (Table 1). Subsequently, we discuss a comparative analysis of the comparison of the clusters, including outliers, for each of the six macroeconomic indicators with box-and-whisker plots (Figures 4-9). Lastly, the mean values for each cluster over time (three 5-year periods) are presented (Figures 10-15).

Ward's method (Figure 1, 2 and 3) divided post-communist countries into three homogeneous groups for each of the three time periods (5 years per one time period 2000-2014). For the 2000-2004 time period (Figure 1) and the 2005-2009 time period (Figure 2), Cluster 1 included Armenia, Azerbaijan, Georgia, the Kyrgyz Republic, Moldova, Mongolia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. For the same time periods (2000-2004 and 2005-2009) Cluster 2 included Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Kazakhstan, FYR Macedonia, Romania, the Russian Federation and Serbia. Lastly, Cluster 3 included Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic and Slovenia.

Clusters 1, 2 and 3 remained with the same countries for the 2005-2009 time period (Figure 2) as determined in the prior time period (2000-2004).However, as shown in Figure 3 for the 2010-2014 time period, a slightly different set of countries for Clusters 1 and 2 resulted when compared to prior time periods. Unlike the two prior time periods, in 2010-2014 Azerbaijan and Turkmenistan were no longer in Cluster 1, but were in Cluster 2.

To verify meaningful differences between or among the clusters of evidence, it is appropriate to use methods that define such differences. To identify indicators that are of a significantly different level in one cluster compared to another, the Kruskal-Wallis rank test procedure was used. The Kruskal-Wallis test is a rank-based non-parametric test that can be used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable.

The Kruskal-Wallis test does not assume normality in the data and is much less sensitive to outliers, thus it can be used when these assumptions have not been met. The Kruskal-Wallis rank test was performed on Clusters 1, 2 and 3. This analysis indicates that statistically significant differences between clusters one, two and three at the 0.05 level of significance are seen in the following variables: GDP per capita, GDP per capita growth, Inflation GDP deflator, Agriculture value added, Total natural resources rents, Services etc. value added. The the Variable GDP per capita growth was not significantly different in the analysed period of 2000-2004. The conclusions are based on p-values (see Table 1), which were compared with the level of significance (α = 0.05).

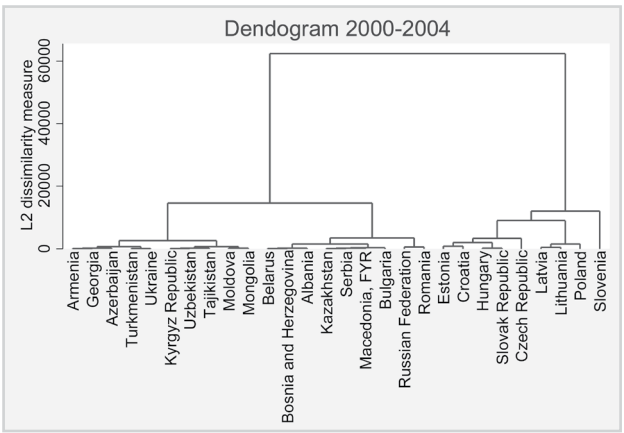

Fig. 1: **Dendogram of clusters for the 2000-2004 period**
Source: Authors' calculations

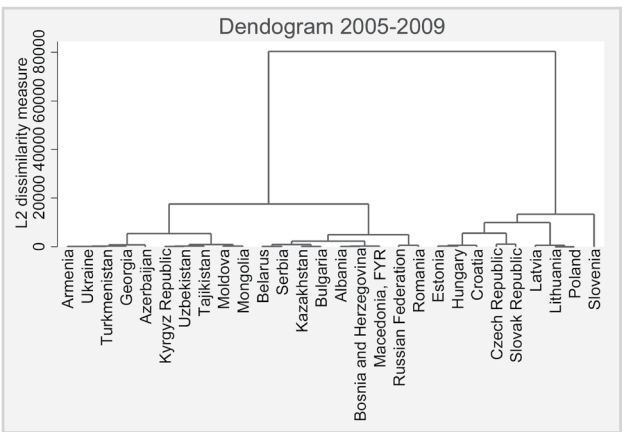

Fig. 2: **Dendogram of clusters for the 2005-2009 period**
Source: Authors' calculations

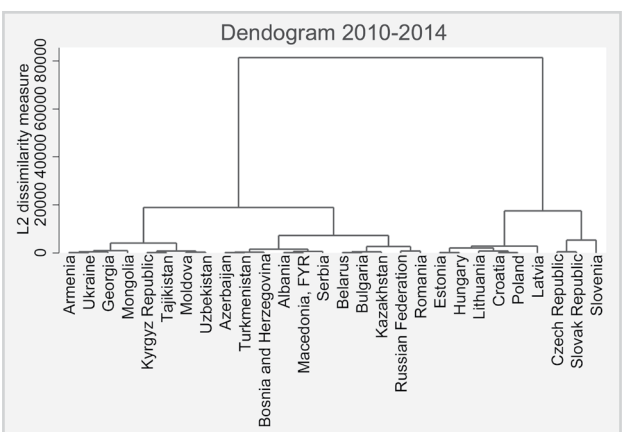

Fig. 3: **Dendogram of clusters for the 2010-2014 period**
Source: Authors' calculations

Tab. 1: **Results of Kruskal-Wallis test, evidence of significant differences between Cluster 1, Cluster 2 and Cluster 3 at level of significance α=0.05**

p-Value	2000-2004	2005-2009	2010-2014
GDP per capita (constant 2005 US$)	0.0001	0.0001	0.0001
GDP per capita growth (annual %)	0.6008	0.0181	0.044
Inflation, GDP deflator (annual %)	0.0159	0.0023	0.001
Gross capital formation (% of GDP)	0.2258	0.8881	0.3968
Foreign direct investment, net inflows (% of GDP)	0.9472	0.3369	0.1626
Agriculture, value added (% of GDP)	0.0001	0.0001	0.0001
Industry, value added (% of GDP)	0.7752	0.8011	0.2424
Total natural resources rents (% of GDP)	0.015	0.0084	0.0051
Services, etc., value added (% of GDP)	0.0001	0.0072	0.0273

Source: Own calculations

For six variables that have statistically significant differences between Clusters 1, 2 and 3, we have plotted box-and-whiskers plots as shown in Figures 4-9. They allow us to show summary statistics that clearly show results of a comparative analysis and show summary statistics as lower and upper whiskers, first quartile, median, mean, third quartile and interquartile range. Whiskers extend to the furthest observation that is no more than 1.5 interquartile ranging from the edges of the box. Mild outliers are plotted in Figures 5, 7 and 8, and include Turkmenistan, Albania and Mongolia. They have values of the analysed indicators between 1.5 and 3 interquartile ranging from the edges of the box. The extreme outlier is plotted in Figure 6. Belarus, with values of the indicator «Inflation» greater than a 3 interquartile ranges from the edges of the box. The specific unit of each indicator is shown in the chart title and specific values are displayed along the horizontal axis of box-and-whiskers plot.

While two goals of the paper were to analyse the disparity and identify significant differences of post-communist countries, we were also interested in analysing the dynamics of economic characteristics over the course of the 2000-2014 time period, given dissimilarity measures and time trend of mean values of economic characteristics.

The vertical axis of dendrograms depicted in Figures 1, 2 and 3 show an L2 dissimilarity measure. As you go up the vertical axis, the dissimilarity measure increases. The Euclidean

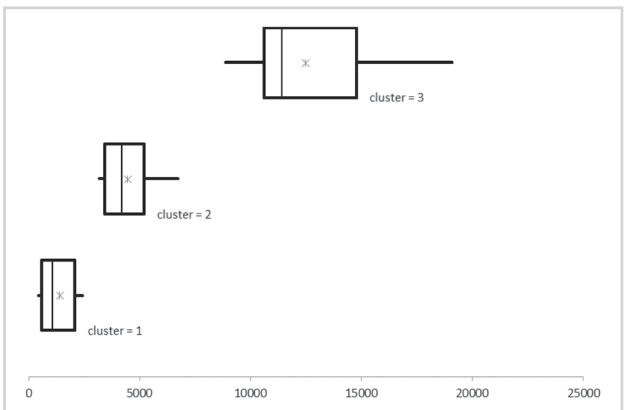

Fig. 4: **Box-and-whiskers plot of comparison of average value of GDP per capita (constant 2005 US$) in 2010-2014**
Source: Authors' calculations

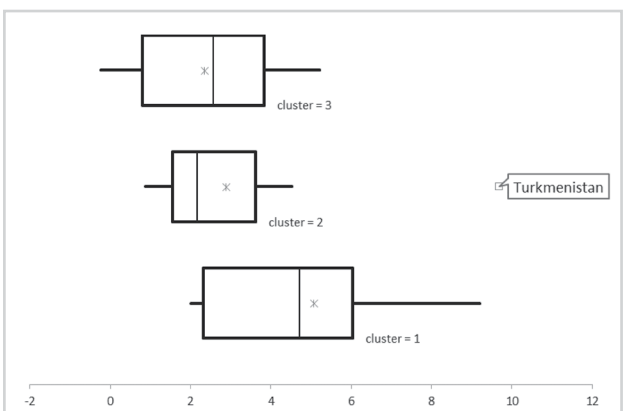

Fig. 5: **Box-and-whiskers plot of comparison of GDP per capita growth (annual %) in 2010-2014**
Source: Authors' calculations

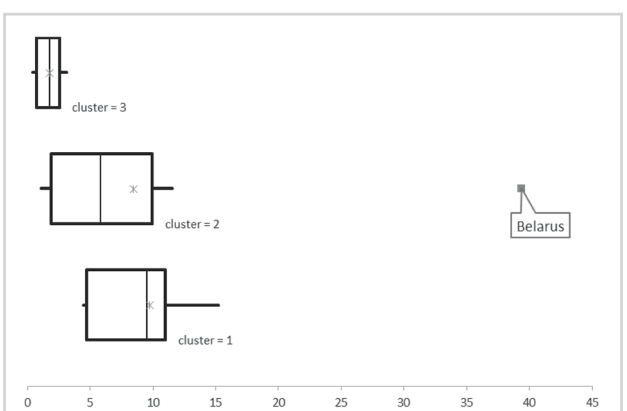

Fig. 6: **Box-and-whiskers plot of comparison of inflation, GDP deflator (annual %) in 2010-2014**
Source: Authors' calculations

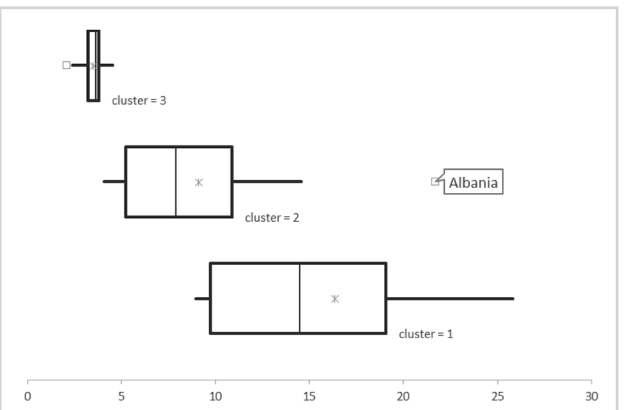

Fig. 7: **Box-and-whiskers plot of comparison of agriculture, value added (% of GDP) in 2010-2014**
Source: Authors' calculations

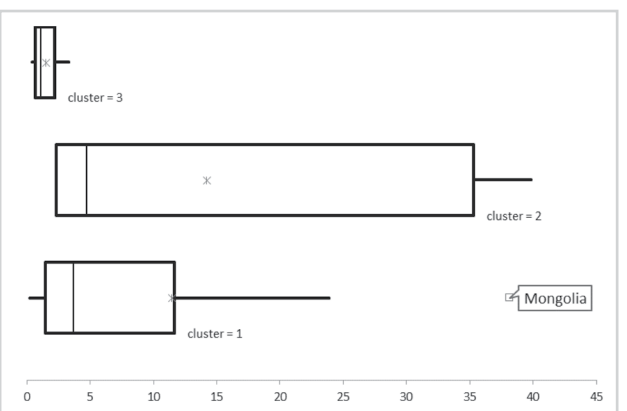

Fig. 8: **Box-and-whiskers plot of comparison of total natural resources rents (% of GDP) in 2010-2014**
Source: Authors' calculations

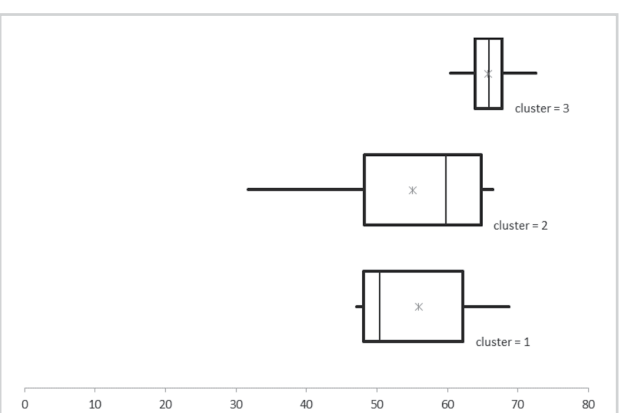

Fig. 9: **Box-and-whiskers plot of comparison of services etc. value added (% of GDP) in 2010-2014**
Source: Authors' calculations

distance that represents the dissimilarity measure between Cluster 1 and Cluster 2 has a value significantly less than 20,000 at the start of the analysed period but at the end reaches a value of 20,000. The value of the dissimilarity measure between Cluster 3 and the remaining clusters increases from 62,000 in 2000-2004 to 80,000 by the last period of 2010-2014. Based on the dissimilarity measures, it is possible to conclude there are divergent trends among post-communist countries.

The plotted charts in Figures 10-15 depict the mean values of the analysed variables and the trend over the time periods. Figure 10 shows the increasing trend in the «GDP per capita» variable for all the three clusters.

Figure 11 demonstrates the generally decreasing trend of the «GDP per capita growth» variable for all the three clusters, although Cluster 1 increased from 2000-2004 to 2005-2009.

Figure 12 reveals the decrease in the «Inflation, GDP deflator» variable for all three clusters over the period.

Figure 13 reflects the decreasing trend in the «Agriculture, value added (% of GDP)» variable for all the three clusters.

Figure 14 shows that trends in the «Total natural resources rents» variable differ for all the three clusters. Cluster 1 exhibits a rapid increase in 2000-2004 and 2005-2009, followed by a decrease. Cluster 2 exhibits an increase after a slight decrease. Cluster 3 demonstrates a stable decrease.

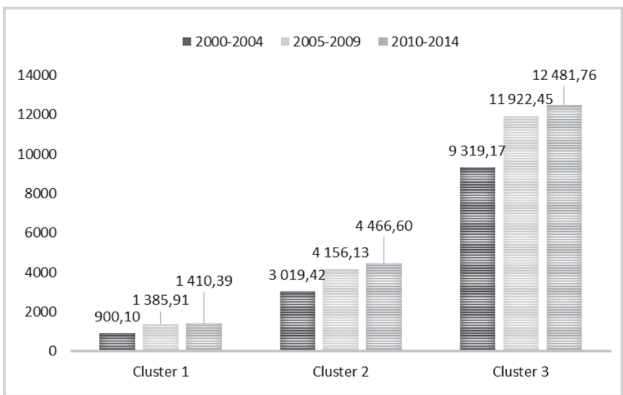

Fig. 10: **Mean values of «GDP per Capita (constant 2005 US$)» variable in 2000-2004, 2005-2009 and 2010-2014**
Source: Authors' calculations

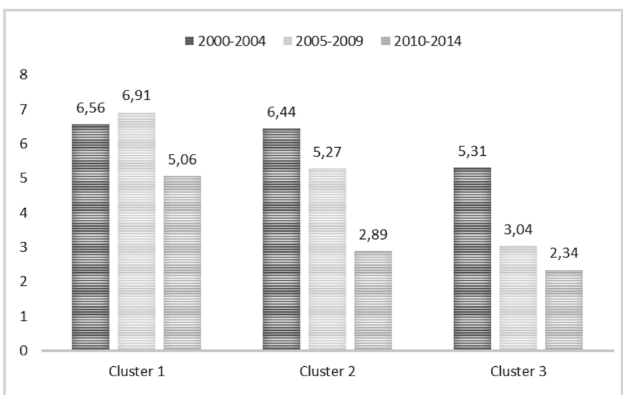

Fig. 11: **Mean values of «GDP per Capita Growth (Annual %)» variable in 2000-2004, 2005-2009 and 2010-2014**
Source: Authors' calculations

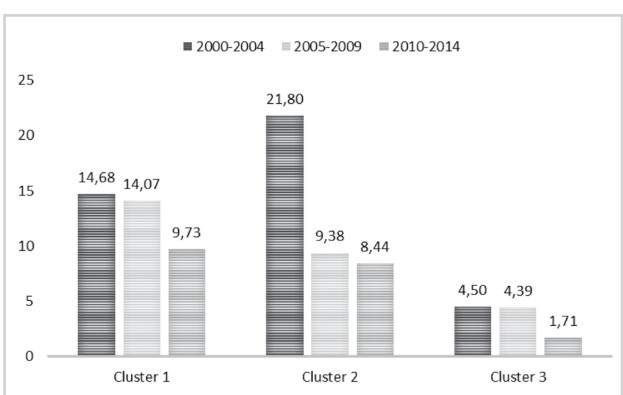

Fig. 12: **Mean values of «Inflation, GDP Deflator (Annual %)» variable in 2000-2004, 2005-2009 and 2010-2014**
Source: Authors' calculations

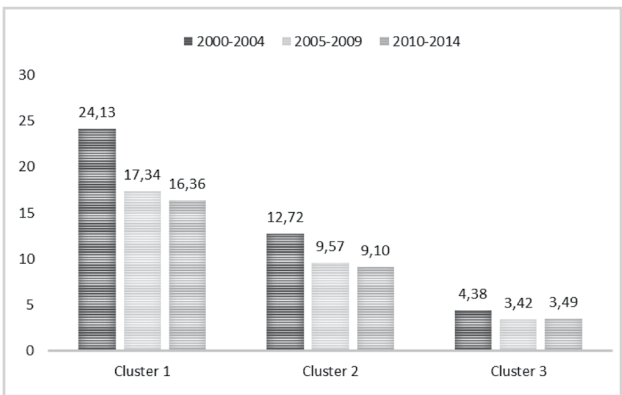

Fig. 13: **Mean values of «Agriculture, value added (% of GDP)» variable in 2000-2004, 2005-2009 and 2010-2014**
Source: Authors' calculations

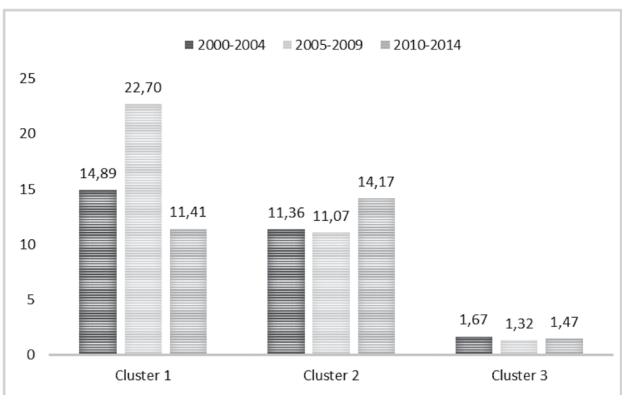

Fig. 14: **Mean values of «Total Natural Resources Rents (% of GDP)» variable in 2000-2004, 2005-2009 and 2010-2014**
Source: Authors' calculations

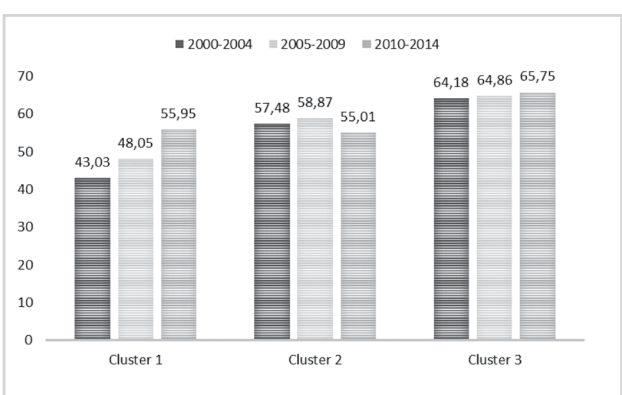

Fig. 15: **Mean values of «Services, etc., Value Added (% of GDP)» variable in 2000-2004, 2005-2009 and 2010-2014**
Source: Authors' calculations

Figure 15 depicts a decreasing trend in «Services etc. value added» variable for Cluster 2 and an increasing trend for Clusters 1 and 3.

5. Conclusions

Taking into consideration the results obtained by applying Ward's method of clustering we have been able to group post-communist countries into three relatively homogeneous clusters. The first cluster consisted of Armenia, Azerbaijan, Georgia, Kyrgyz Republic, Moldova, Mongolia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan in 2000-2004, although Azerbaijan and Turkmenistan were in Cluster 2 for 2010-2014. The second cluster was represented by Albania, Belarus, Bulgaria, Kazakhstan, FYR of Macedonia, Romania, the Russian Federation, Serbia, Bosnia and Herzegovina in the 2000-2004 period. The third group of countries comprised countries such as Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland and the Slovak Republic.

The Kruskal-Wallis rank test indicates the presence of statistically significant differences between and among clusters (0.05 level of significance) for a number of the analysed variables, including GDP per capita, GDP per capita growth, Inflation GDP deflator, Agriculture value added, Total natural resources rents, Services etc. value added. The only exception is GDP per capita growth, which was not significantly different in 2000-2004. The conclusions are based on p-values, which have been compared with values appropriate to the level of significance ($\alpha = 0.05$).

Although all countries in our research were post-communist countries, their economic trajectory after communism was far from identical. We found consistent evidence that post-communist countries differ with respect to social and economic dynamics and can be grouped into three clusters. Moreover, each of these clusters is significantly different from one another. Our results strongly suggest that sharing a common past can influence possible economic futures, but this is not deterministic in any strict sense. As for the post-communist countries in our study, the presence of more than one cluster strongly suggests that the realisation of particular outcomes of an economic future is likely to be a function of common strategies of national development within each cluster.

Forthcoming progressive development in Clusters 1 and 2 depends on the capability of countries-constituents to follow the effective transition models implemented in the EU member states, which form Cluster 3. A positive convergence originates from modern European values backing up the EU economy of diversity and inclusion, if they are implemented and adjusted to fit national cultural patterns. Institutional shifts to overcome the current heterogeneity of post-communist evolution outcomes are beyond the scope of this particular article and form the agenda of our future research.

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