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ECONOMIC PERFORMANCE IN POST-SOVIET AND POST-COMMUNIST COUNTRIES – EVIDENCE FROM PANEL DATA AND MULTIVARIATE STATISTICAL ANALYSIS

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Abstract

The study examines the effect of sets of determinants of economic growth, which are widely emphasised in the literature, in a group of 27 selected post-Soviet, post-communist and transition countries from Central and Eastern Europe, the former Soviet Union, and Mongolia during 1997–2017. The set of baseline variables includes, among others, trade openness, investment rate, public consumption spending, and selected demographic factors. The methodology uses panel data and it is supported by multivariate statistical methods of grouping objects. The panel data provides results that are mainly consistent with the literature review. However, the effects of demographic factors are rather not significant, but the role of investment has been emphasised. In turn, the multivariate statistical approaches indicate the shifts in regional (dis)similarity between the analysed countries with respect to the performance of the selected variables over the last 20 years.

Keywords: *Panel data, post-Soviet countries, transition countries, post-communist countries, multivariate approach*

JEL classification: *C23, O50, R11*

1. Introduction

Post-Soviet and post-communist countries at the end of the 20th century experienced a challenging and long process of transition. During that period these economies underwent different structural changes, took part in integration processes (such as an enlargement of the European Union or setting up the Eurasian Economic Union), were engaged in numerous political, institutional, demographic or regional transformations.

The analyses of determinants of economic growth have been one of the issues that focuses the attention of the growth researchers. The comprehensive overview of the theories of economic growth and their evolution is presented in Barro and Sala-i-Martin (2003), among others. However, the growth issues, in the theoretical and empirical discussions and debates, have been dominated by two approaches – exogeneous (neoclassical) growth theories and endogenous growth theories. A neoclassical Solow-Swan model (Solow 1956; Swan 1956), emphasizing the role of

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physical capital accumulation in growth determinants, is a seminal example of exogenous growth model. The extensions of the model (e.g., see the so-called Ramsey-Cass-Koopmans model or a model by Mankiw, Romer, and Weil 1992, among others) sought to better explain the growth determinants (e.g. by inclusion of human capital as in the case of Mankiw-Romer-Weil model), but still seemed to be unable to explain them on the background of the long-term determinants of the economic growth. As a result a new generation of models – endogenous growth models – appeared as a tool to explore the determinants of long-term growth (e.g., the so called *AK model* (see e.g. Rebelo 1991), or models proposed by Lucas 1988; Romer 1986, 1990; Grossman and Helpman 1991, among others) based not only on "quantitative" determinants (labor, physical capital) but mainly on the "qualitative" productivity factors: human capital, technological progress, activity of the research and development sector, among others. These two types of models have become a base for numerous empirical analyses of the growth.

The literature regarding the determinants of medium- and long-term growth is large and provides a set of different explanatory variables (see: Barro and Sala-i-Martin 2003; Sala-i-Martin, Doppelhofer, and Miller 2004; Barro 1991, 2003; Durlauf, Johnson, and Temple 2005, among others). For example, Sala-i-Martin, Doppelhofer, and Miller (2004) investigate 67 explanatory variables and find that nearly one fifth of them can be recognised as being robustly partially correlated with long-term growth. Taking into account the results; however, only three variables can be strongly identified as being marginally related: the relative price of investment, primary school enrolment, and the initial level of real GDP *per capita*. The importance of initial income or gross fixed capital formation, as robust determinants of growth, is emphasised, for example, by Levine and Renelt (1992). The important roles of physical capital, human capital, public investment, trade openness, and population growth rate upon economic growth in 98 countries are analysed, for example, by Knight, Loayza, and Villanueva (1993). However, depending on the country sample or the methodology used, some studies present dubious results. The attention related to the growth in the post-Soviet, transition or post-communist countries is a subject of interest from Katchanovski (2000), who examines the divergence of economic growth in post-Soviet countries.

In general, in the case of the majority of studies, physical capital is positively associated with economic growth (Barro 1999, 2003; Bleaney, Gemmell, and Kneller 2001). The role of investment is emphasised in endogenous and exogenous growth models, but, taking into account the obtained results, some outcomes report not fully conclusive results. In the case of the theoretical relationship between trade openness and economic growth, the majority of the studies provide the conclusion that trade affects growth positively (Romer 1992; Barro and Sala-i-Martin 2003; Dollar and Kraay 2004; Tahir and Azid 2015). However, Krugman (1994) or Rodriguez and Rodrik (2001) argue that the impact of trade upon growth is dubious. Theoretical and empirical studies emphasize the role of foreign direct investment or human capital in growth determinants (Mankiw, Romer, and Weil 1992; Benhabib and Spiegel 1994; Hanushek and Kimko 2000; Iwasaki and Suganuma 2005, 2015; Nicolini and Resmini 2010; Neycheva 2013, among others), but the data availability and completeness often determine a set of possible variables used in a balanced panel data. The initial level of real GDP *per capita* is often recognised as a measure that reflects the concept of conditional convergence, and the negative effect of the variable on growth was supported, for example, by Barro (1996) or Sala-i-Martin (1994). Regarding fiscal policy, in Barro (1991, 1996), public consumption is inversely related to growth. A similar conclusion is formulated by Afonso and Jalles (2011), who take into account and investigate a panel of 108 countries from 1970–2008, that, in general, government consumption negatively influences growth. Due to the inconclusive evidence, however, some authors propagate the nonlinear relationship between government size and growth (e.g. Barro 1989; Armey 1995). Furthermore, the role of fiscal policy is investigated by analysing the effects of debt and many studies are aimed at investigating the nonlinear relationship (e.g. Kumar and Woo 2010; Reinhart and Rogoff 2010; Baum, Checherita-Westphal, and Rother 2013; Égert 2015). This is due to the ambiguous effect of debt on economic growth, especially that the high level of debt potentially negatively influences the GDP growth rate. Another category of determinants is associated with demography, whose effect is often analysed through the use of variables capturing the population growth rate, the structure of society or the concept of population ageing (Bruce and Turnovsky 2013; An and Jeon 2006, among others). Barro (1996), in his study, analyses a set of demographic factors and he states that the population growth rate negatively influences GDP growth. A higher fertility rate is expected to affect growth negatively (Barro 1996, 1999, 2003; Checherita-Westphal and Rother 2012), but Kelley (1988) concludes that estimated coefficients may be negative for less developed economies and positive for developed economies.

The aim of the presented study is twofold: to analyse the effects of selected determinants on growth and to provide the statistical delimitation of countries with the example of a broader sample of 27 countries over the last 20 years. The motivation behind that goal derives from the literature review. The time samples and country samples used in existing studies are limited, mainly due to the potential problems associated with data availability. The brief of the literature review provides a remark that there is a gap for analyses based on a wider sample of post-communist, post-Soviet and transition countries. Thus, the proposed analyses contribute to the literature because they allow evaluating the effects of the most important theoretical determinants of growth — trade openness, investment rate, initial level of GDP and, additionally, public consumption — in the context of a wider sample of countries in transition, post-Soviet countries and post-communist countries, over the period of 1997–2017. Moreover, the time sample used covers the period of the severe recession that occurred at the end of the first decade of the 21st century and also covers the post-crisis recovery times. The motivation of this study is also associated with the interest in examining the differences in factors driving growth, singling out countries with similar characteristics of economic performance and investigating the importance of these factors in creating the fragmentation of countries. Growth in the 27 countries is on various paths. However, the analysis of shifts in the (dis)similarity of the selected countries over the last 20 years seems to be valuable and contribute to the literature. Therefore, the comparison of the created groups of countries for 1997 and 2017 allows preparing conclusions on the potential regional shifts in similarity related to the performance of the most important growth determinants in these countries. The additional originality of the proposed contribution is that it supplements the standard econometric approach with the multivariate statistical analysis of post-Soviet, post-communist, and transition countries. The presented study shows a combined result related to growth and its determinants.

The paper is structured as follows. The first section presents data and methodology. The following section aims to explain the results. The subsequent section provides a discussion and points to some limitations of the study. The final section includes a summary of the study and provides concluding remarks.

2. Materials and methods

2.1. Panel data – data and methodology

The data used in this study derives mainly from the World Bank - World Development Indicators database. The initially derived set of data includes annual data from 1995–2018 and concerns a group of 32 post-Soviet, post-communist and transition countries. However, much of the data is not available for all countries. As a result, in order to receive a balanced panel, the sample is limited to a group of 27 countries, while the time sample is restricted to the years 1997–2017. Finally, the country list includes: Albania, Armenia, Azerbaijan, Belarus, Bulgaria, China, Croatia, Czechia, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Mongolia, North Macedonia, Poland, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Tajikistan, Ukraine, and Uzbekistan.

Due to the relatively small size of the sample, a limited number of variables determining economic growth have been chosen. The baseline specification is controlled by variables that are very often used in economic growth analysis, i.e. trade openness, i.e. the indicator of the sum of exports and imports, expressed as a percentage of GDP (Rodriguez and Rodrik 2001), the investment rate (Barro and Sala-i-Martin 2003), and the initial level of GDP. The last-mentioned variable is expressed in this study by the initial level of the natural logarithm of real GDP *per capita* — aimed at capturing the rate at which the poorer countries within the sample catch up with the wealthier countries. The choice of that variable, instead of a lagged dependent variable, was made in order to avoid the use of dynamic panel data, due to the fact that the approach employed is based on the calculated non-overlapping intervals; as a result, a low amount of the panel data is available. The relationship between this variable and growth is expected to be negative (see, for example, Borys, Polgar, and Zlate 2008; Barro and Sala-i-Martin 2003 for details). It should be emphasized that the country sample in this study seriously affects a set of variables possible to be included in the growth analysis, due to the data availability. Therefore, the international cooperation is controlled by trade openness variable and, for example, capital inflows and outflows in the form of foreign direct investment variable are not included. Due to the same problem with data completeness, the variable capturing human capital is not included – the school enrolment ratios in different levels of education are not completed for all countries and are incomparable over the analyzed time and country sample.

The estimated specification also includes general government consumption spending, expressed as a percentage of GDP. It is one of the variables included in the analysis of economic growth. For example, Barro (1991) estimates the negative effect of government spending or its components on output in the case of a group of OECD countries and/or developing countries. The set of baseline variables was extended by additional control variables such as the population growth rate or the age dependency ratio. The additionally mentioned control variables capture the relationship between demography and growth.

In this paper, as in similar studies, the baseline estimates are not provided for data in annual frequencies, but rather are adjusted to non-overlapping periodic intervals (see, for example, Kumar and Woo 2010; Borys, Polgar, and Zlate 2008; Dollar and Kraay 2004), especially five-year-averaged non-overlapping intervals. Non-overlapping intervals help to avoid an impact of short-run cyclical innovations, i.e. dynamics in business cycle results. The use of intervals is an attempt to capture the long-term relationship, which should not be subject to short-run cyclical behaviour. However, a disadvantage of this approach is the small sample of observations in comparison to annual data.

Due to the application of a common approach, the original sample covering annual data from 1997–2017 has been divided for intervals consisting of simple averages of non-overlapping five-year periods for each variable (i.e. 1997–2001, 2002–2006, 2007–2011, 2012–2016, and the last interval for the single year of 2017). As a result, the "time" sample includes only five intervals. Details of all data included in this approach and the descriptions of intervals are presented in Table 1A in Appendix. As a result, the panel data, as mentioned previously, is strongly balanced.

The general, standard equation used for intervals (labelled as T) is as follows (see e.g. Wooldridge 2010):

$$y_{i,T} = \beta x_{i,T} + \mu_i + \eta_T + \varepsilon_{i,T} \qquad (1)$$

where $y_{i,T}$ is dependent variable, $x_{i,T}$ is a vector of determinants, μ_i denotes country-specific effect, η_T denotes time-specific effects, and $\varepsilon_{i,T}$ is the error term. The equation (1) can be converted to (2):

$$gdp\_pc\_gr_{i,T} = \alpha_1 ln\_gdp\_pc_{i,Tb} + \alpha_2\, trade_{i,T} + \alpha_3 inv_{i,T} + \beta x'_{i,T} + \mu_i + \eta_T + \varepsilon_{i,T} \qquad (2)$$

where $gdp\_pc\_gr_{i,T}$, $ln\_gdp\_pc_{i,Tb}$, $trade_{i,T}$, and $inv_{i,T}$ are defined in Table 1A in Appendix and $x'_{i,T}$ is a vector of other control determinants.

Initially, for intervals, due to the potential endogeneity, the instrumental variables estimator is used. The chosen approach is related to two-stage least squares (IV 2SLS) estimator (see Wooldridge 2010; Baltagi 2008 for details).

Moreover, the analysis is also extended by the use of annual data (as comparable analysis), which is similar to the approach used by Borys, Polgar, and Zlate (2008), among others. Taking into account the literature review, in the cases of analyses based on annual data (resulting in a larger-sized panel) an additional variable was applied in the estimated specifications, i.e. the debt-to-GDP ratio. It is used as a control variable only in the specifications based on annual frequencies, because of the limited availability of that variable for all countries considered. The variable is derived from the IMF Historical Public Debt Database, but, as mentioned, it is not available for each year of the all 27 countries analysed. Moreover, the availability of data for the debt-to-GDP ratio is smaller than the used sample (the last available year is 2015). As a result, the country list in specifications with the debt-to-GDP ratio includes only 21 countries (excluding Bulgaria, Mongolia, North Macedonia, Serbia, Tajikistan, and Uzbekistan). The effects of demographic factors are also analysed through the use of the fertility rate. However, the variable is not available for Serbia until 1999.

In the case of the annual data the estimation method uses dynamic panel data. Due to the inclusion of a lagged dependent variable, the specifications presented do not include the convergence indicator in the form of the previously used logarithm of real GDP *per capita* in the initial period. As a result, equation (1) is adjusted. The employment of different estimators is applied for robustness checks. Estimates are obtained through the use of first differenced GMM (FDGMM) estimator by Arellano and Bond (1991). The additional method applied in this paper for annual frequency is the bias-corrected LSDV dynamic panel data estimator that uses the bias approximations by Bruno (2005) for unbalanced panels. In this study the Arellano–Bond approach is chosen to initialise the bias correction. Furthermore, additional estimators are employed for robustness checks.

2.2. Multivariate analysis – cluster analysis, and k-means approach

The extension of the econometric approach is based on the evaluation of the (dis)similarities between the analysed post-Soviet countries, post-communist countries and transition countries from the point of view of the real GDP *per capita* growth rate and the main determinants of growth used in this paper. In order to achieve that goal, two multivariate statistical methods for grouping objects have been employed.

The first approach used is a hierarchical clustering method in the form of cluster analysis. Cluster analysis is an agglomeration technique which is one of the hierarchical methods of grouping countries. The aim of cluster analysis is to join in cluster objects (in this case countries) which are similar, taking into account the implementation of the selected set of variables. In general, the fewer the similarities between objects, the greater the distance between them. The method allows creating clusters from available objects (Cleff 2019). The initial N objects consist of the N clusters (with each object in a separate cluster) and in further steps the number of those clusters is reduced until all N objects are linked in one cluster (Mojena 1977). The last linkage joins objects with the lowest level of similarity. In general, the goal of the analysis is to find a small number of homogeneous clusters (Timm 2002).

In cluster analysis, important elements are related to the choice of distance measurement and the linkage methods for agglomerative hierarchical clustering. The methods for agglomerative clustering differ in the way of determining the distance between the objects analysed (see, for example, Wishart 1969). In the study presented, Ward's method (Ward 1963), as a linkage method, and the Euclidian distance have been used. Ward's method links clusters that optimise a criterion, which is the error sum of squares.

The second approach used in this paper is the k-means method. The k-means approach is recognised as an efficient clustering method (Lloyd 1982; MacQueen 1967). The algorithm is based on the minimisation of the squared error between the empirical mean of a cluster and the points in the cluster.

Agglomerative cluster analysis allows for distinguishing the number of clusters (groups) of objects that are similar with respect to the implementation of a set of variables. In this study the number of obtained clusters, in subsequent steps, is employed within the k-means clustering. It is due the fact, that the results of clustering obtained by the use of the k-means approach vary depending on the number of cluster parameter changes. As a result, in this study, the "k" number of clusters inputted into the k-means algorithm is derived from the number of clusters obtained using the agglomerative cluster analysis. It is considered to be an optimal choice. The number of objects included in both approaches (i.e. agglomerative cluster analysis and k-means approach) consists of all 27 countries analysed. In order to compare the potential shifts of these countries between groups, two separate analyses are presented — for 1997 and for 2017 (i.e. the beginning and the end of the full sample). The aim of this comparison is to observe the potential shifts in similarities between countries or their regional "convergence" or "divergence" over the last 20 years. The set of analysed variables focuses on those mostly used in the growth literature and employed in this study in the baseline growth regressions, i.e.: $gdp\_pc\_gr_{i,t}$, $trade_{i,t}$, $inv_{i,t}$, $pop\_gr_{i,t}$, and $cons\_exp_{i,t}$.

Next, the correlation matrix has been built separately for the years 1997 and 2017 in order to analyse the quality of the data and its informative values. The results presented confirm that the set of five variables applied can be used in the multivariate analysis (see Tables 6A and 7A in Appendix). All variables used in further steps of the multivariate analyses have been standardised.

3. Results

3.1. Panel data – baseline approach and robustness checks

Initially, a two-stage least squares method with fixed effects robust to heteroskedasticity and the cluster option has been used. However, the endogeneity test for baseline variables indicates that there is no reason to reject the null upon which the specified variables are exogenous. A set of potentially endogenous regressors includes variables such as: general government final consumption expenditure, investment rate, trade openness, population growth rate, and age dependency ratio. Due to the small size of the panel, each of the potential variables has been instrumented by its lag. When the potentially endogenous variable has been instrumented by another set, the test occurs against rejecting its null. In fact, the test indicates that some variables can be treated as endogenous (see Table 4A in Appendix), but the Hansen J-statistic obtained (related to the over-identification test of all instruments) is not satisfactory and indicates rejecting its null. Moreover, as mentioned, the use of a higher number of lags for instrumented variables caused the endogeneity test to fail to reject the null. Due to numerous problems with regard to receiving all desired properties, the decision has been made not to use that approach. As a result, the two-stage least squares method has not been employed and the usual fixed effects model with a cluster option has been applied in baseline estimations.

The specifications presented, except for the results shown in columns 1–2, 5 and 10 of Table 1 below, include time dummies for single intervals.

Table 1. Estimated coefficients – data in intervals

	1	2	3	4	5	6	7	8	9	10
$ln\_gdp\_pc_{i,Tb}$	-3.972*** (0.725)	-3.820*** (0.665)	-7.508*** (1.685)	-7.403*** (1.803)	-3.683*** (0.924)	-8.043*** (1.977)	-8.134*** (1.817)	-7.662*** (1.411)	-7.497*** (1.693)	-4.022*** (0.559)
$trade_{i,T}$	0.030** (0.014)	0.033** (0.013)	0.004 (0.014)	0.003 (0.014)	0.033** (0.013)	0.017 (0.013)	0.017 (0.013)		0.004 (0.014)	0.033** (0.013)
$inv_{i,T}$	0.177*** (0.054)	0.216*** (0.045)	0.129*** (0.044)	0.128*** (0.044)	0.217*** (0.048)	0.122** (0.043)	0.122** (0.044)	0.124*** (0.040)	0.129*** (0.044)	0.214*** (0.045)
$cons\_exp_{i,T}$	-0.112 (0.198)	-0.097 (0.197)	-0.047 (0.144)	-0.032 (0.159)	-0.081 (0.209)	0.143 (0.661)	-0.009 (0.133)	0.025 (0.759)	0.046 (0.762)	0.553 (0.936)
$cons\_exp^2{}_{i,T}$						-0.005 (0.019)		-0.002 (0.022)	-0.003 (0.022)	-0.019 (0.028)
$pop\_gr_{i,T}$				-0.226 (0.695)	-0.254 (0.810)	-0.154 (0.668)				
$adr_{i,T}$						-0.125** (0.050)	-0.125** (0.050)			
Crisis		-1.282** (0.524)			-1.278** (0.530)					-1.261** (0.522)
Constant	32.6809*** (6.719)	30.104*** (6.631)	61.997*** (15.807)	60.872*** (17.113)	28.688*** (9.119)	69.689*** (19.867)	72.007*** (17.133)	63.152*** (14.110)	61.177*** (17.410)	26.747*** (8.584)
Time dummies	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No
R-squared (within)	0.3218	0.3588	0.5979	0.5987	0.3598	0.6198	0.6192	0.5976	0.5980	0.3630
Obs.	135	135	135	135	135	135	135	135	135	135
Countries	27	27	27	27	27	27	27	27	27	27

Robust standard errors are presented in brackets. Signs *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.
Source: Author's own compilation

The estimates presented in Table 1 show the positive effect of the investment rate upon the real GDP *per capita* growth rate in the group of countries analysed. The effect is statistically significant in the case of each of the specifications investigated. The obtained relationship between trade and growth indicates that trade openness positively affects the dependent variable, but, as presented, the estimated coefficients, even those statistically different from zero, generally are very close to zero. However, the inclusion of the time dummies causes the relationship between trade openness and the real GDP growth rate to become not statistically significant. The specifications presented also include spending on general government consumption. As shown, the effect of the variable is negative, as mainly investigated in the literature review, but the estimated relationship is not statistically significant. As a result, it does not confirm that public consumption, on average, surely slows down growth in the countries analysed. In order to check for potential nonlinearity, the variable for averages for squared consumption government spending ($cons\_exp^2{}_{i,T}$) has been used in the specifications (see columns 6 and 8 - 10). However, the estimated coefficients are not statistically significant.

Columns 2, 5 and 10 of Table 1 show parameter estimates for the specifications including the crisis dummy variable. It is the variable with a value of 1 for the interval presenting averages for the years 2007–2011 and a value of 0 for the remainder of the four intervals calculated. The variable shows that in the crisis' interval, the real GDP *per capita* growth rate was, on average, lower in comparison to the alternative intervals. The estimated effect is that of nearly 1.3 on average.

The parameter reflecting the effect of the logarithm of real GDP *per capita* in the year prior to each interval is negative and statistically significant. In general, it indicates convergence among the post-Soviet countries, post-communist countries and transition countries and exhibits the process in which the poorest countries catch up with the more advanced countries, which is an important implication of the neoclassical growth models in line with the fundamental Solow (1956) model. The obtained effect of the variable on growth is negative, which is consistent with the hypothesis.

Taking into account columns 4 – 6 of Table 1, the specifications were extended by the population growth rate. The effect of that variable on the real GDP *per capita* growth rate in the countries analysed is negative, which is a result consistent with the main stand of the growth literature, but the effect is not statistically significant. The inclusion of the age dependency ratio increases R-squared, as reflected by the statistically significant effect of that variable upon the dependent variable. The relationship between the age dependency ratio and growth is negative, which is a finding in line with the majority of studies, as a higher ratio of non-working-age population to working-age population results in a lower real GDP *per capita* growth rate.

As previously mentioned, the study also aims to analyse annual data because of the short sample of data presenting in intervals and due to its potential impact on the results. The findings, as an additional comparable analysis, are presented in Appendix in Table 5A. The specifications in Table 5A, similar to previous estimates, take into account the crisis dummy variable ($Crisis_{\_2009}$). In this case, however, a value of 1 is for 2009 and a value of 0 is for the remaining years. The dummy variable aims to capture the large economic downturn in 2009 experienced by these countries.

The results for dynamic panel data are presented in Table 5A in columns 1 - 6. The additional use of instrumental variable methods (columns 7-14) has been accompanied by the endogeneity test for a set of baseline variables. The test indicates that there is no reason to reject the null upon which the majority of specified variables are exogenous (and while controlling the results of the over-identification test of all instruments). One of the exceptions is related to the investment rate. The estimates are presented in Table 5A in Appendix in columns 7-14.

As shown, regardless of a set of different variables typically used in growth regressions, in the case of dynamic panel data the estimated coefficient of the lagged dependent variable is positive and statistically significant (see Table 5A in Appendix). However, it is slightly higher in the case of the use of the bias-corrected LSDVC estimator. The coefficients for the investment rate and trade openness are positive. Those findings are supported by the estimates obtained from the sample based on intervals. The estimated coefficients for these two variables, if statistically significant, are quite similar in the case of specifications based on non-overlapping intervals and annual data. However, the effect of trade openness in the case of specifications obtained by the use of the FDGMM estimator is insignificant, regardless of the set of other control variables employed in the regressions. Generally, the relationship between public consumption and dependent variable is negative, as obtained in the specifications estimated for non-overlapping intervals, but, contrary to the previous approach, rather significant. It is also opposite to Hsieh and Lai (1994), who based on the example of the G7, point out that there is no evidence that public spending stimulates or destimulates the growth of GDP *per capita*.

The inclusion of a debt variable is reflected in columns 3, 6, 10, and 14 of Table 5A. As presented, the relationship between debt and growth is negative. This result may show that in the group of countries analysed in this specification (i.e. narrower group of 21 countries), public debt might have had an effect on these economies and slowed down the growth. Generally, the effect of the population growth rate is not significant. The relationship between fertility rate and economic growth is negative.

3.2. Multivariate analysis and grouping countries

The correlation matrix for standardised variables represents the possibility of using all variables in the agglomerative cluster analysis and the k-means approach (see Tables 6A and 7A in Appendix).

Results of the clustering are presented in dendrograms in Figures 1A and 2A (in Appendix) for the years 1997 and 2017, respectively. Analyses of the structures for 1997 and 2017, supported by an evaluation of the heterogeneity of the post-Soviet countries, post-communist countries and transition countries, allow for grouping the countries and extracting clusters. The proposed structure of separated clusters is presented in Table 2.

As shown, the approach used allows for extracting five clusters in 1997 and five in 2017. In 1997 the groups named Cluster* 4 and Cluster* 5 differ from Clusters* 1–3, which is reflected by the largest (and latest) linkage between the agglomeration created by these two clusters (i.e. Cluster* 4 and Cluster* 5) and the agglomeration created by the remaining three clusters (i.e. Clusters* 1, 2 and 3). In general, in the case of 1997, the approach used does not display a visible division of the countries between "European" countries and the remainder of the countries analysed. It is worth mentioning that a large enlargement of the EU, which affected the group of countries considered, was in 2004 — in that year the EU was extended to include the following countries analysed in this paper: Czechia, Hungary, Latvia, Lithuania, Poland, Slovak Republic, and Slovenia. Bulgaria and Romania joined

Table 2. Structure of clusters in 1997 and 2017 – delimitation based on agglomerative cluster analysis

1997	Cluster* 1	Cluster* 2	Cluster* 3	Cluster* 4	Cluster* 5
	Serbia, Poland, Russian Federation, North Macedonia, Tajikistan, Mongolia, Kyrgyz Republic	Ukraine, Moldavia, Slovenia, Hungary, Latvia, Lithuania, Croatia, Estonia, Belarus	Slovak Republic, Czechia, Uzbekistan, China, Azerbaijan	Georgia, Kazakhstan, Armenia	Bulgaria, Romania, Albania
2017	Cluster* 1	Cluster* 2	Cluster* 3	Cluster* 4	Cluster* 5
	Slovak Republic, Hungary, Estonia, Czechia	Lithuania, Latvia, Croatia, Ukraine, Slovenia, Poland, Serbia, Bulgaria	Romania, Moldavia, Armenia	Tajikistan, Kyrgyz Republic, China	Mongolia, Uzbekistan, Kazakhstan, Azerbaijan, Russian Federation, North Macedonia, Belarus, Georgia, Albania

Source: Author's own compilation

the EU in 2007 and Croatia in 2013. As a result, in 2017 the structure of the created clusters exhibits a more distinct division between the EU countries and the remainder of the countries analysed. It insinuates that there was a shift in the similarities in performance between the countries analysed in this study over the last 20 years with respect to the variables selected. Taking into account the results presented in the form of dendrograms, in 2017 it is possible to distinguish two "blocks" of countries. The first "block" is more "European" and includes countries grouped in Clusters* 1–3, while the second one includes countries grouped in Clusters* 4–5.

The number of clusters distinguished in the agglomerative approach is used to deepen the investigation aimed at optimal grouping of countries within the k-means approach. As a result, the k-means approach has been prepared by creating five (arbitrary) groups of objects in 1997 and 2017. The results of grouping are presented in Table 3 below. As shown, the structure of the created clusters (within analysis of a separate, single cluster) is similar to those obtained in the agglomerative cluster analysis.

The analysis of the structure of created groups was supplemented by the plots of means for these clusters obtained using k-means clustering, as presented in Figures 3A–4A in Appendix. Taking into account the results supported by an analysis of within-group and intergroup variances, short characteristics of the grouped countries may be formulated.

In 1997, countries grouped in Cluster 1 (Belarus, Czechia, Estonia, Hungary, Lithuania, Moldavia, Slovak Republic, and Slovenia) constituted countries with the highest mean for the ratio of consumption spending to GDP and the highest mean for the population growth rate. Countries grouped in Cluster 3 (Albania,

Table 3. Structure of clusters obtained in the k-means algorithm

1997	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
	Belarus, Czechia, Estonia, Hungary, Lithuania, Moldavia, Slovak Republic, Slovenia	Croatia, North Macedonia, Poland, Russian Federation, Serbia, Ukraine, Latvia	Albania, Armenia, Bulgaria, Georgia, Kazakhstan, Romania	Kyrgyz Republic, Mongolia, Tajikistan	Azerbaijan, China, Uzbekistan
2017	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
	China, Kyrgyz Republic, Tajikistan	Belarus, North Macedonia, Russian Federation, Serbia	Bulgaria, Croatia, Czechia, Estonia, Hungary, Lithuania, Poland, Slovak Republic, Slovenia, Ukraine, Latvia	Albania, Armenia, Georgia, Moldavia, Romania	Azerbaijan, Kazakhstan, Mongolia, Uzbekistan

Source: Author's own compilation

Armenia, Bulgaria, Georgia, Kazakhstan, and Romania) were characterised by the lowest means for the following variables: population growth rate, investment rate, consumption spending, and real GDP *per capita* growth rate. The plot of means indicates that Cluster 1 consists of countries for which the mean for real GDP *per capita* growth rate was the highest.

In the case of 2017, the plot of means indicates that countries grouped in Cluster 1 (China, Kyrgyz Republic, and Tajikistan) were characterised by the lowest mean for the share of trade in GDP, and the highest means for the following variables: population growth rate, and investment rate. Cluster 5 was characterised by countries with one of the lowest mean for real GDP *per capita* growth rate and the lowest mean for the share of public consumption in GDP. The highest means for the following variables: share of public consumption, the ratio of trade to GDP, and the lowest mean for the investment rate, and also a relatively low mean for the variable that captures the level of population growth were concerned with countries grouped in Cluster 3. Taking into consideration the division of countries in 2017 into five groups, the highest mean for real GDP *per capita* growth rate was related to those countries assigned to Cluster 4 (Albania, Armenia, Georgia, Moldavia, and Romania).

4. Discussion

The study shows a set of analyses based on the relationships between growth and selected dependent variables. The considered group of countries in the 1990s experienced divergence in economic growth rates and the levels of variables determining growth; over the last 20 years, however, the countries have reached important shifts that are partly consistent with their regional integrations.

The empirical findings are mainly in line with the literature review. These apply to the relationship between growth and the investment rate (consistent, for example, with Mankiw, Romer, and Weil 1992; Barro 2003) or between growth and trade openness (Barro and Sala-i-Martin 2003; Dollar and Kraay 2002). The study confirms strong evidence reported by the significance of the estimated parameters concerning the impact of the initial level of GDP upon growth, which is confirmed in both the intervals and the annual data. As mentioned, on the basis of the literature review, neoclassical models predict that a country's *per capita* growth rate tends to be negatively related to its starting level of income *per capita*. In this study, this is supported in the example of a group of post-Soviet and post-communist countries and transition countries.

The two approaches used for presenting data (five-year non-overlapping intervals and annual data) provide different conclusions on the significance of the estimated parameters. This problem is related to the frequency of the data and also to the different estimation methodologies applied for both frequencies. In particular, the annual frequency is perceived to be susceptible to economic fluctuations. General government consumption expenditure has no statistically significant effect on the real GDP *per capita* growth rate in intervals, but the estimated relationship is negative. Additional analysis does not confirm the nonlinear relationship between growth and public consumption, taking into account the insignificance of the estimated coefficients. The effect of the demographic factors analysed in this study is negative, which is also consistent with the majority of literature.

The multivariate analyses imply some interesting facts about the group of countries considered. The agglomerative clustering employed indicates that between 1997 and 2017 the countries analysed experienced a change in structural characteristics that was reflected by the shifts of the countries between clusters over the last 20 years. For 2017 a more visible division of the countries has been investigated between more "European" countries and the remainder of the "Eurasian" countries, which seems to be consistent with the integration processes. Thus, a simple regional displacement of the post-Soviet, post-communist and transition countries was noticed. The division especially seems to be confirmed in the case of the use of the k-means approach. Taking into account the results reported by the k-means algorithm, the structure of the grouped countries for 2017 is clearly marked from a regional point of view. In particular, the shift of the countries arranged in integration with the European Union is visible between 1997 and 2017. In the case of the Eurasian countries the integration concerns, for example, the Eurasian Economic Union (EAEU), which was introduced in 2014. In 2017 its members comprised Belarus, Kazakhstan, Russian Federation, Armenia, and Kyrgyz Republic, but these countries were situated in different clusters created using the k-means approach (see Table 3). However, the last linkage generated in agglomerative clustering (see Figure 2A), which represents the highest level of dissimilarity between the two groups in 2017, confirms the division of the country sample into two blocks of countries (the "Eurasian" agglomeration is distanced from the more "European" clusters).

Such geopolitical integration creates challenges for the Eurasian countries and generates a set of perspectives (Roberts and Moshes 2016). It seems that the findings obtained in this study may contribute to the debate surrounding the processes of integration, especially by taking into account the process of catching up economies, as confirmed in this study. The countries analysed have been arranged into many different integration processes, but two of importance are the EU and the EAEU. Such integration may support strategies for promoting growth, as well as improving and developing intra- and inter-cooperation. However, the cost of integration is the loss of full independence in domestic-level policies aimed at trade, fiscal or other sectorial aspects.

5. Conclusions

The aim of the paper is to analyse the economic performance with the example of a group of 27 countries from Central and Eastern Europe, the former Soviet Union, and Mongolia over the last 20 years. Empirical verification of the relationships between growth and commonly used theoretical determinants is based on panel data. As presented, the findings in the majority of cases are consistent with the literature review. The results indicate that the effect of public consumption or population growth rate is negative, but not statistically significant in non-overlapping intervals. The effect of trade openness and the investment rate is positive, but the significance is not robust and it depends on the estimation methods utilised as well as the way of presenting data. The role of initial GDP is strongly emphasised and the relationship between the real GDP *per capita* growth rate and the initial level of real GDP *per capita* is negative and statistically significant. The multivariate statistical analyses used point to the regional shifts of the countries with respect to the similarity between the performance of the growth variable and the basic growth determinants between 1997 and 2017.

The study presents a set of findings related to growth analyses in the selected post-Soviet, post-communist and transition countries. However, the results should be considered with caution because of the small size of the time sample as well as problems with the availability of other variables important for growth analyses, which may affect the methodology employed, the results, and cause problems with the data. In this context, an analysis including the relationship between growth and variables controlling the human capital or the importance of foreign direct investment in transition countries, post-Soviet countries and post-communist countries may be a valuable extension of this study. Thus, there appears to be an area for further research and extensions.

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APPENDIX

Table 1A. Definitions of variables in intervals*

Panel with non-overlapping intervals T, where T is a 5-year average over periods 1997-2001, 2002-2006, 2007-2011, 2012-2016, 2017	
Variable	Explanation
$gdp\_pc\_gr_{i,T}$	Simple average of real GDP *per capita* growth rate for intervals
$ln\_gdp\_pc_{i,Tb}$	Natural logarithm of real GDP *per capita* in the year before the start of each intervals, i.e. Tb for 1996, 2001, 2006, 2011, and 2016
$trade_{i,T}$	Simple average of trade openness (measured as a sum of import and export in relation to GDP) for intervals
$inv_{i,T}$	Simple average of gross fixed capital formation as a percentage of GDP for intervals, i.e. investment rate
$pop\_gr_{i,T}$	Simple average of population growth rate for intervals
$adr_{i,T}$	Simple average of age dependency ratio, measured as a ratio of people younger than 15 or older than 64 to the working-age population (15 - 64) and expressed for 100 working-age population
$cons\_exp_{i,T}$	Simple average of general government final consumption expenditures as a percentage of GDP for intervals

* all calculations based on World Bank data (World Development Indicators)

Table 2A. Descriptive statistics – data in intervals

Variable	Obs.	Mean	Std. dev.	Min	Max
$gdp\_pc\_gr_{i,T}$	135	4.362	2.890	-1.451	17.192
$inv_{i,T}$	135	24.210	6.040	10.262	43.254
$trade_{i,T}$	135	98.242	33.733	35.684	188.131
$cons\_exp_{i,T}$	135	16.657	3.387	9.377	23.451
$pop\_gr_{i,T}$	135	0.057	0.924	-2.247	2.470
$adr_{i,T}$	135	48.666	7.684	35.098	87.398

Table 3A. Descriptive statistics – annual data

Variable	Obs.	Mean	Std. dev.	Min	Max
$gdp\_pc\_gr_{i,t}$	567	4.424	4.741	-14.379	32.997
$inv_{i,t}$	567	24.447	6.847	6.296	57.710
$trade_{i,t}$	567	96.668	33.615	22.492	188.131
$cons\_exp_{i,t}$	567	16.746	3.684	8.119	28.806
$pop\_gr_{i,t}$	567	0.039	1.065	-9.081	7.786
$debt_{i,t}$ (*)	399	36.115	22.665	3.66	159.41
$fr_{i,t}$	586	1.776	0.614	1.085	4.332

(*) $debt_{i,t}$ – denotes data for 21 countries, coverage: 1997-2015.

Table 4A. Endogeneity test – intervals

Independent variables	$cons\_exp_{i,T}, inv_{i,T}, trade_{i,T}, ln\_gdp\_pc_{i,Tb}$	$cons\_exp_{i,T}, inv_{i,T}, trade_{i,T}, ln\_gdp\_pc_{i,Tb}, pop\_gr_{i,T}$	$cons\_exp_{i,T}, inv_{i,T}, trade_{i,T}, ln\_gdp\_pc_{i,Tb}, pop\_gr_{i,T}, adr_{i,T}$
Endogeneity test for:	χ^2 p-value		
$cons\_exp_{i,T}$	0.1181	0.0886	0.1181
$inv_{i,T}$	0.2579	0.3137	0.3020
$trade_{i,T}$	0.0762	0.0542	0.0457
$pop\_gr_{i,T}$	-	0.5906	0.9296
$adr_{i,T}$	-	-	0.0724

Table 5A. Parameter estimates – annual frequency, robustness check. Dependent variable $gdp\_pc\_gr_{i,t}$:

	FDGMM			LSDVC			IV 2SLS				IV GMM			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
$gdp\_pc\_gr_{i,t-1}$	0.317*** (0.064)	0.285*** (0.075)	0.324*** (0.071)	0.423*** (0.037)	0.395*** (0.034)	0.370*** (0.042)								
$ln\_gdp\_pc_{i,t,-1}$								-5.566*** (0.685)	-4.870*** (0.785)	-6.972*** (0.842)		-5.529*** (0.673)	-4.816*** (0.771)	-6.835*** (0.813)
$trade_{i,t}$	0.028 (0.022)	0.027 (0.020)	0.029 (0.023)	0.016* (0.008)	0.020** (0.010)	0.033*** (0.020)	0.021** (0.010)	0.032*** (0.011)	0.033*** (0.010)	0.068*** (0.013)	0.022** (0.010)	0.031** (0.010)	(0.032)*** (0.010)	0.065*** (0.012)
$inv_{i,t}$	0.123* (0.071)	0.183** (0.073)	0.072 (0.063)	0.094*** (0.030)	0.103*** (0.030)	0.017 (0.039)	0.143** (0.062)	0.187*** (0.062)	0.191*** (0.061)	0.012 (0.079)	0.151** (0.061)	0.184** (0.061)	0.188*** (0.060)	0.008 (0.079)
$cons\_exp_{i,t}$	-0.724*** (0.185)	-0.704*** (0.188)	-0.887*** (0.259)	-0.207** (0.090)	-0.246*** (0.094)	-0.292** (0.126)	-0.293** (0.118)	-0.467*** (0.119)	-0.482*** (0.115)	-0.853*** (0.159)	-0.314*** (0.112)	-0.454*** (0.111)	-0.465*** (0.105)	-0.812*** (0.144)
$pop\_gr_{i,t}$	-0.041 (0.340)	0.033 (0.260)	0.058 (0.251)	-0.252 (0.183)	0.003 (0.221)	-0.281 (0.256)	-0.543 (0.405)	-0.007 (0.192)	0.013 (0.186)	-0.129 (0.187)	-0.556 (0.404)	-0.007 (0.192)	0.131 (0.186)	-0.128 (0.187)
$Crisis_{\_2009}$	-8.638*** (1.130)	-8.276*** (0.857)	-8.825*** (1.344)	-8.685*** (0.648)	-8.455*** (0.601)	-9.568*** (0.881)	-8.254*** (1.176)	-7.136*** (1.103)	-7.101*** (1.081)	-7.064*** (1.224)	-8.224*** (1.175)	-7.154*** (1.101)	-7.125*** (1.079)	-7.146*** (1.217)
$debt_{i,t}$			-0.039 (0.031)			-0.062*** (0.015)				-0.126*** (0.018)				-0.124*** (0.018)
$fr_{i,t}$		-10.448*** (2.985)			-3.573*** (0.895)				-3.317*** (1.208)				-3.352*** (1.204)	
Obs.	513	511	357	513	511	357	513	513	512	357	513	513	512	357
Countries	27	27	21	27	27	21	27	27	27	21	27	27	21	21
AR(1) p-value	0.001	0.002	0.005											
AR(2) p-value	0.286	0.219	0.112											
Sargan Prob > χ^2	0.275	0.317	0.458											
Endogenity test for $inv_{i,t}$							2.471 (p-value 0.116)	2.217 (p-value 0.137)	1.788 (p-value 0.181)	1.357 (p-value 0.244)	2.471 (p-value 0.116)	2.217 (p-value 0.137)	1.788 (p-value 0.181)	1.357 (p-value 0.244)
Hansen J-statistic p-value							0.587	0.775	0.720	0.536	0.587	0.775	0.720	0.536

SEs are presented in brackets. *, ** and *** represent significance at the 10%, 5% and 1% levels, respectively. FDGMM – first differenced GMM dynamic panel data estimator, two-step procedure, robust SEs; LSDVC – bias-corrected LSDV dynamic panel data estimator, with bias correction initialised by Arellano-Bond approach, 50 repetitions; IV 2SLS – IV two-stage least squares, fixed effects, and robust SEs and cluster option; IV GMM – IV two-step feasible GMM estimation, fixed effects, and robust SEs and cluster option

Table 6A. Correlation matrix – year 1997

1997	$trade_{i,t}$	$pop\_gr_{i,t}$	$inv_{i,t}$	$cons\_exp_{i,t}$	$gdp\_pc\_gr_{i,t}$
$trade_{i,t}$	1.000				
$pop\_gr_{i,t}$	0.093	1.000			
$inv_{i,t}$	0.144	0.270	1.000		
$cons\_exp_{i,t}$	0.293	0.084	0.110	1.000	
$gdp\_pc\_gr_{i,t}$	0.141	-0.160	0.250	0.217	1.000

Table 7A. Correlation matrix – year 2017

2017	$trade_{i,t}$	$pop\_gr_{i,t}$	$inv_{i,t}$	$cons\_exp_{i,t}$	$gdp\_pc\_gr_{i,t}$
$trade_{i,t}$	1.000				
$pop\_gr_{i,t}$	-0.348	1.000			
$inv_{i,t}$	-0.363	0.445	1.000		
$cons\_exp_{i,t}$	0.461	-0.294	-0.122	1.000	
$gdp\_pc\_gr_{i,t}$	-0.001	-0.334	0.050	0.177	1.000

Figure 1A. Dendrogram for the year 1997

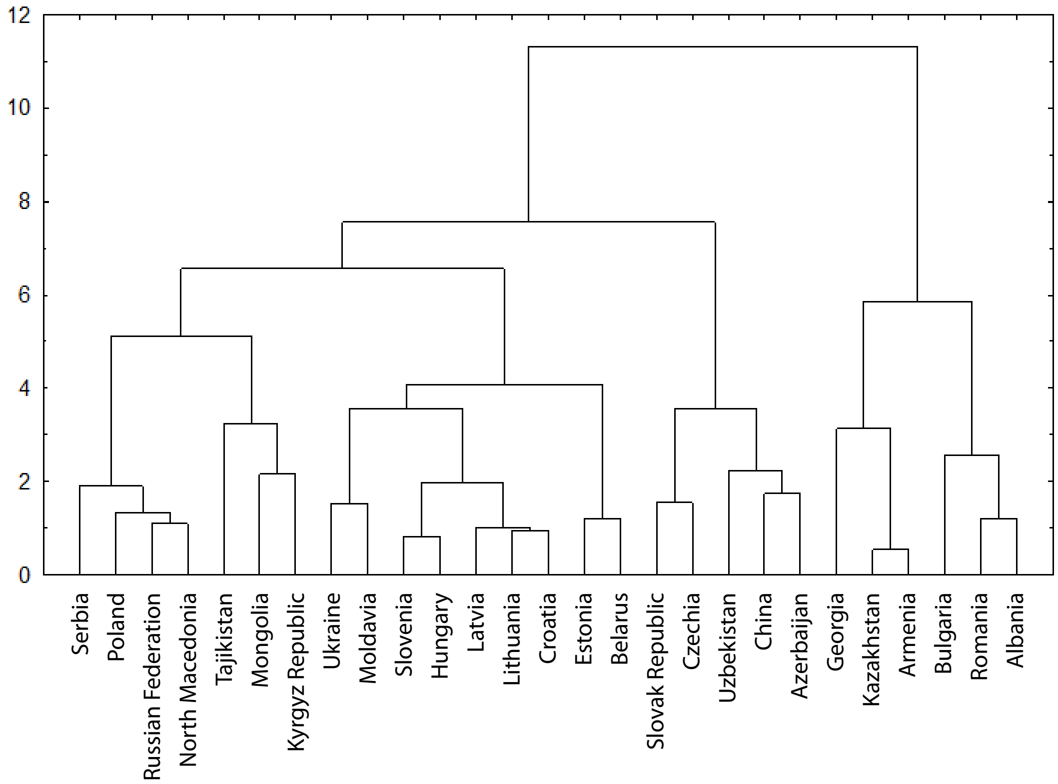

Figure 2A. Dendrogram for the year 2017

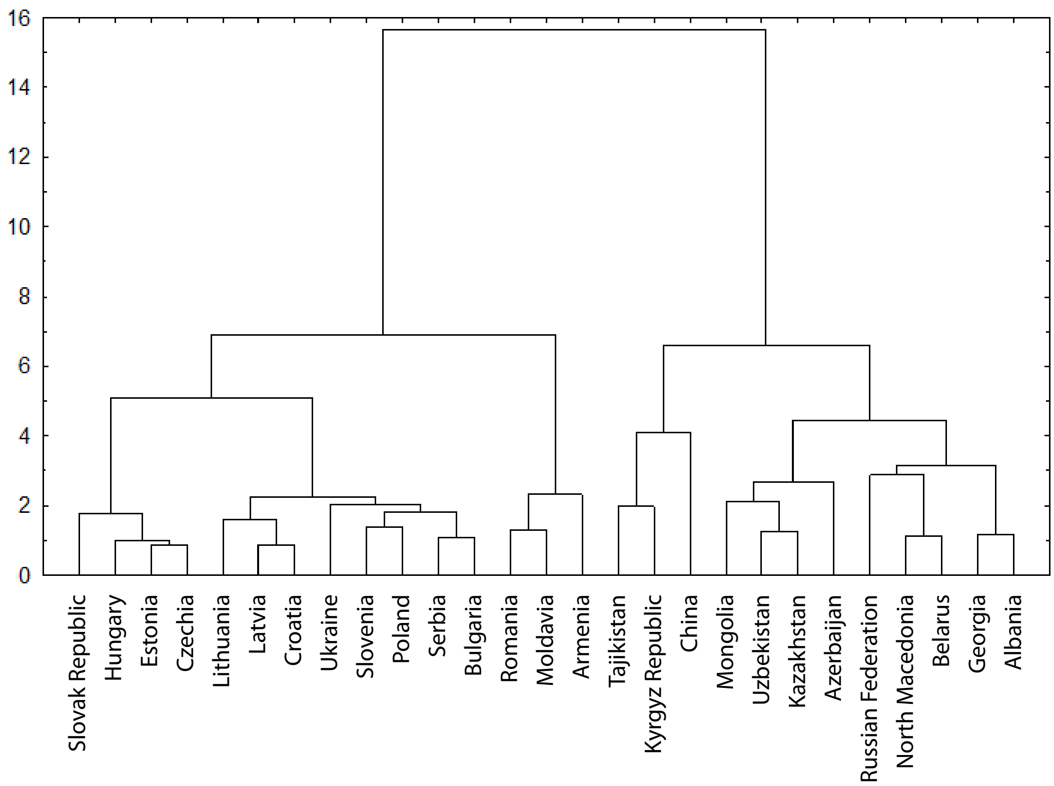

Figure 3A. Plot of means for clusters obtained for the year 1997

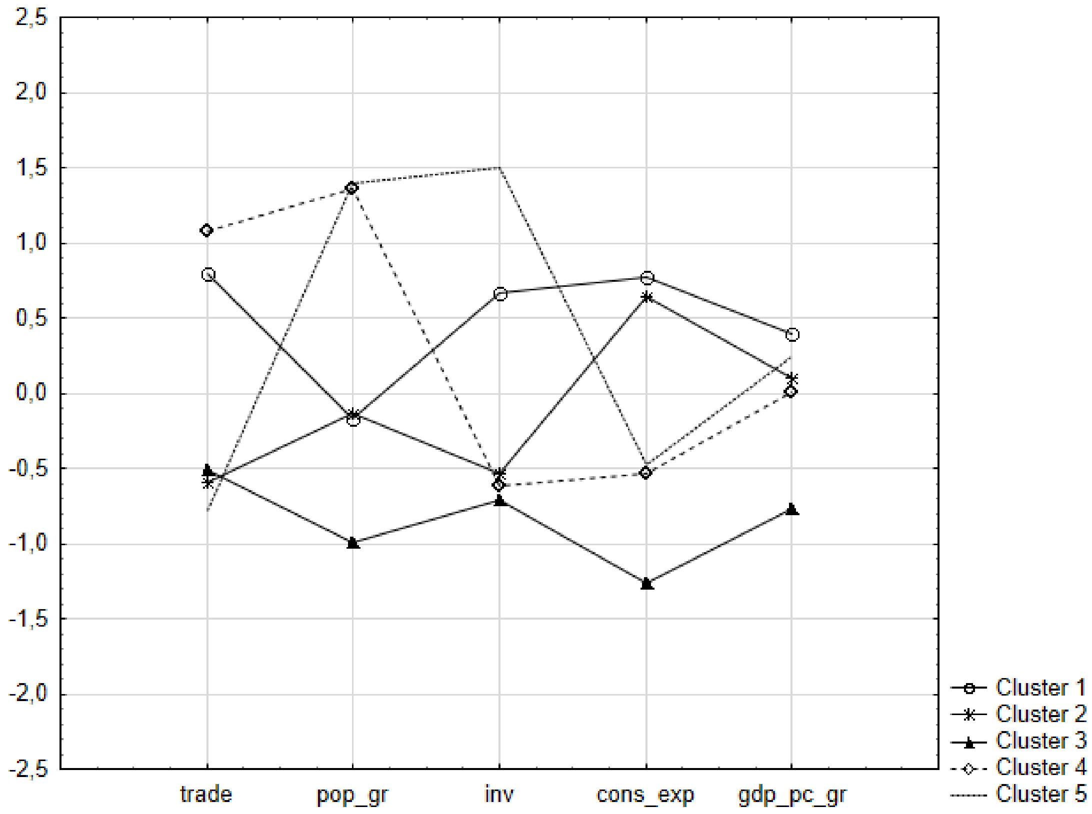

Figure 4A. Plot of means for clusters obtained for the year 2017