Mihajlović, Vladimir; Miladinov, Goran

Article

Impact of population ageing on economic growth in emerging EU countries

Ekonomický časopis

Impact of Population Ageing on Economic Growth in Emerging EU Countries

Vladimir MIHAJLOVIĆ – Goran MILADINOV***

Abstract

This study aims to investigate the effect of one of the most prominent contemporary changes in demographic structure, population ageing, on the economic performance of eight emerging economies from Central and Eastern Europe. Despite experiencing relatively high economic growth, these countries are still striving to catch up with the more advanced European economies (which are used as the control group). Concurrently, they are facing significant population ageing. Using the Pooled Mean Group estimator in the panel ARDL model, the study finds that a one percent increase in the old dependency ratio results in a 0.52 percent decrease in GDP per capita growth rate and a 0.53 percent decrease in GDP growth rate in the long term. The gross capital formation rate and the gross savings positively impact per capita economic growth in the short term, whereas the labour force participation rate's impact on the GDP growth varies across the country groups. The findings underscore the importance of implementing active ageing programs, creating fiscal buffers, fostering lifelong learning, and promoting employment among vulnerable groups to mitigate the adverse effects of population ageing on economic growth in emerging economies.

Keywords: *Central and Eastern Europe, emerging economies, economic growth, old de-pendency ratio, ARDL (PMG) model*

JEL Classification: B22, C33, E24, J11, N30

DOI: https://doi.org/10.31577/ekoncas.2024.01-02.03

Article History: *Received*: December 2023 *Accepted*: May 2024

* Vladimir MIHAJLOVIĆ, University of Kragujevac, Faculty of Economics, Liceja Kneževine Srbije 3, 34000 Kragujevac, Republic of Serbia; e-mail: vmihajlovic@kg.ac.rs

** Goran MILADINOV, independent researcher, UKIM in Skopje, Faculty of Economics, Boulevard Goce Delchev 9, 1000 Skopje, Republic of Macedonia; e-mail: miladinovg@aol.com

Introduction

Population ageing is one of the most pronounced changes in the demographic structure of the modern world (Prskawetz et al., 2008). It is a part of demographic transition, a heterogeneous process consisted of the secular increase of life expectancy, the transition of boom and bust of babies, fertility dynamics, and migration flows. All these tendencies do not necessarily affect the population size but inevitably change its structure (Börsch-Supan et al., 2019).

At EU level, the old-age dependency ratio, as a measure of population ageing, is projected to increase from 33.0% in 2022 to 59.7% by 2100. Most of this growth will take place at a rapid pace from 2022 to 2060, when it is projected to reach 53.0%, followed by a relatively flat decade high, and then a slow growth to 59.7% by 2100. Among EU member states, the highest old-age dependency ratios in 2100 are projected for Malta (68.2%), Lithuania (66.2%) and Italy (65.7%), while the lowest is projected for the Czech Republic (54.1%) and Sweden (54.8%). Furthermore, the old-age dependency ratio in 13 EU member states is projected to be higher than 50.0% up to 2050. Put differently, there will be less than two working-age persons for each person aged 65 and over. In addition, for three EU member states – Greece, Portugal and Italy – the old-age dependency ratio is projected to be higher than 60.0% by 2050 (Eurostat, 2024).

These demographic transformations have significant macroeconomic implications. First of all, ageing can produce a drop in the labor force participation rate, if the cohorts leaving the labor market are larger than the cohorts that enter the market (youth population). Fewer workers in the labor force are likely to produce lower output. Further, labor productivity can decrease because of the deterioration of older workers' physical and cognitive abilities due to ageing (Aksoy et al., 2019; Lee and Shin, 2021). In other words, the population ageing tends to reduce the economic growth.

However, this impact could be mitigated by investing in more productive technologies (Acemoglu and Restrepo, 2017; Lee and Song, 2020). Furthermore, parallel to the so-called accounting effect, based on the increase of the dependent population share, the behavioral effect also occurs and contributes to the mitigation of the ageing effects on the economy. The changes related to this effect refer to the fertility decline and consequently rise in the labor force participation by women, as well as an increased human capital investment in children, a decrease in youth dependency, and higher rates of savings due to the increased rate of longevity (Bloom et al., 2015). In addition, the demographic transition characterized by a decline in fertility and mortality rates can lead to the demographic dividend emergence, producing more rapid growth of the workforce compared to the growth of the dependent population (young and old). As a corollary, the resources become available for investment in economic development and family welfare (Lee and Mason, 2006).

In European countries, the population ageing is the result of the long-term decline in fertility rates and increased life expectancy due to advances in public health and medical technologies, the promotion of healthy lifestyles and improved living conditions (Eurostat, 2020). However, these processes are not equally distributed among different countries. The economies of Central and Eastern Europe (CEE) face a pronounced increase in the old dependency ratios, that is, faster ageing (Tálas and Etl, 2020). This process is related to the population decline which is also present in these countries for decades. Population decline resulted from both the difference between births and deaths (natural population change) and net migration (Fihel and Okólski, 2019). Furthermore, CEE countries are emerging economies which strive to intensify the process of convergence towards the more advanced European countries. Although the economic growth rates in CEE economies are relatively high, this convergence will inevitably be affected by demographic factors in the long run. Hence, the main research question is whether these processes will lead to a decline in economic growth rates and thus slow down the convergence to the most advanced European economies.

Accordingly, this study aims to investigate the impact of the dependency ratio on economic growth among the eight emerging EU (CEE) countries: Bulgaria, Czech Republic, Hungary, Latvia, Slovakia, Slovenia, Poland, and Romania. In the first place, the reason for including these countries is that they are indicated as emerging economies in Europe due to their economic growth since 2000s. Secondly, these eight countries are indicated among the countries in Europe which are experiencing intensive population ageing, and negative population growth or decline of population for a longer period.

The population ageing in these countries is approximated by the old dependency ratio, as a common approach in empirical studies dealing with the economic impact of the elderly share in the total population (i.e. Maestas et al., 2016; Hsu and Lo, 2019; Aksoy et al., 2019; Lee and Shin, 2021). The relative contribution of particular production factors is captured by gross capital formation and the labor force participation rate. In addition, the level of gross savings is also introduced in the model, as it depends on the population age structure. The panel data were used, whereas the research methodology is based on the Autoregressive Distributive Lag (ARDL) approach using Pooled Mean Group (PMG) estimator.

The paper is organized as follows. The second section presents the findings of previous empirical studies and gives the justification for the research focus in this study, the third section explains the methodology, the fourth section provides the results, the fifth contains a discussion and the sixth section concludes.

1. Literature Review

From the very beginning of economic growth theory development, demographic factors have played an important role. The relationship between demographic changes and production has ranged from a pessimistic view that population growth will lead to a fall in GDP per capita (i.e. Malthus, 1826; Solow, 1956; Mankiw et al., 1992) to an optimistic view that a larger population, with a more abundant labor force, will contribute to economic growth (i.e. Kuznets, 1960; Kremer, 1993). In addition, many studies reveal that the relationship between population growth and economic growth is rather ambiguous (i.e. Heady and Hodge, 2009; Huang and Xie, 2013; Mierau and Turnovsky, 2014; Peterson, 2017).

Age structure as an important mechanism behind the impact of demographic variables on economic growth was introduced in a seminal paper by Bloom and Wiliamson (1998). It is argued that it is more plausible that the changes in the age structure, rather than in the total population, lead to changes in the economic growth (Kelley and Schmidt, 2005; Hsu and Lo, 2019). However, the relationship between an increase in the old dependency ratio (i.e., population ageing) and economic growth is yet quite controversial, spanning from negative through neutral to the positive impact of ageing on economic growth. For instance, Cooley and Henriksen (2018) show that the economic growth slowdown in Japan and U.S. can be partly explained by population ageing and increasing life expectancy. Maestas et al. (2016) reveal the negative effect of population ageing on GDP per capita growth in the period 1980 – 2010 in the USA. They discover that 10 percent increase in the share of 60 year and older in the total population leads to a 5.5 percent decrease in GDP per capita. One-third of the decrease is due to slower employment growth whereas two-thirds are due to slower labor productivity growth.

Lee and Shin (2019) analyze data for 142 countries from 1960 to 2014 about the impact of population ageing on economic growth. They reveal that there is a negative effect of ageing on economic growth, but only when the old dependency ratio (used as a proxy for population ageing) reaches a certain threshold. This relationship is nonlinear as the deepening of the ageing problem has a stronger negative impact on economic growth. The same authors (Lee and Shin, 2021) demonstrate that the decline in total factor productivity is the main factor behind the negative impact of population ageing on GDP per capita growth in 35 OECD countries. These findings are also supported by Aksoy et al. (2019) for selected OECD countries, Poplawski-Ribeiro (2020) for observed advanced and emerging market economies, Calvo-Sotomayor et al. (2019), and Andriulis et al. (2022) for European countries. Ahmad and Ali Shah (2021) investigate the impact of dependency ratios for different cohorts on economic growth in the five most populated Asian countries. While both young and total dependency ratios exhibit positive short- and long-run impacts on economic growth, the old dependency ratio affects economic growth negatively, but only in the long run.

One of the commonly considered factors behind the negative effect of population ageing on economic growth is related to the level of savings. Indeed, the relationship between lower savings due to ageing, and economic growth, is straightforward. Since the elderly save less, the rise in the old dependency ratio leads to a decline in aggregate savings, thus lowering capital formation and, finally, reducing economic growth (Nagarajan et al., 2016; Uddin et al., 2016; Hsu and Lo, 2019; Boateng et al., 2019). This viewpoint is founded in the well-known life-cycle hypothesis (Modigliani and Brumberg, 1954). However, some studies indicate the causality from economic growth to saving rate; such is i.e. Andrei and Huidumac-Petrescu (2013) for the case of Euro area economies. These authors find evidence of significant unidirectional causality from real GDP to the saving rate, with a delay of at least four years.

On the other hand, Acemoglu and Restrepo (2017) conclude that there is no negative relationship between population ageing and slower growth of GDP per capita in the OECD and selected non-member countries. The explanation they offer is that the countries with more intensive population ageing have adopted more advanced technologies performing tasks previously undertaken by labor. Similar findings can be found in Acemoglu and Restrepo (2022) for the U.S., and Lee and Song (2020) for Japan and Korea. Pham and Vo (2021) find a positive nexus between the share of elderly (65 and older) in the total population in 84 developing countries in the period 1971 – 2015 and economic growth. According to the authors, the accumulation of capital and assets and the consumption behavior of the older population in these countries are the main factors behind this kind of relationship. Similar findings can be found in Kopecky (2011) and Mason and Lee (2013). By employing the quantile regression approach, they also discover that the youth dependency ratio negatively affects economic growth.

The complementary approach to analyze the shifts in population age structure due to the demographic transition and their impact on economic outcomes is based on the role of demographic dividends. In accord with that, Jafrin et al. (2021) apply pooled OLS model to demonstrate that demographic dividend positively affects GDP growth in five South Asia Association for Regional Cooperation (SAARC) countries. Furthermore, they reveal that labor force participation rate affects economic growth negatively, which can be explained by the lack of skilled workers in the region, the low share of females in the labor force and the high share of informal employment. Although these findings coincide with some earlier studies (i.e., Shahid, 2014; Haque et al., 2019; Afolabi, 2023), Bidisha et al.

(2020) use various econometric techniques to show that an increase in the ratio of workforce to non-working population (i.e., labor participation rate) in selected Asian economies has a positive impact on economic growth in the long run. Bloom et al. (2009) also demonstrated that in the period from 1960 to 2000 for 97 countries there exists positive nexus between the increase in the female labor participation rate (due to a decline in the fertility rate) and economic growth per capita.

The review of the previous empirical studies indicates that there is no consensus concerning the impact of population ageing on economic outcomes. The mechanisms of that impact are realized through changes in productivity, savings rate, capital intensity of production, etc. Furthermore, there is a lack of empirical research dealing with the linkage between changes in population age structure and economic growth (either total or per capita growth) in CEE countries. This is a significant research gap, bearing in mind that these countries face intensive population decline and ageing which could be detrimental to economic outlooks in the medium and long run. Therefore, the contribution of this study is to add further to the knowledge about the influence of population ageing on GDP growth (per capita and total) in selected CEE economies and to provide policy recommendations for preserving the existing economic convergence towards the advanced European economies.

2. Methodology and Data

Bearing in mind the current study investigating the impact of population ageing on economic performance, the panel regression model we start with can be formulated in the following way:

$$GDPpcg_{it} = a_i + b_1 ODR_{it} + b_2 GCF_{it} + b_3 GS_{it} + b_4 LFP_{it} \quad (1)$$

where i denotes the cross-sectional unit and t denotes the time periods. As the commonly analyzed measure of economic performance, GDP per capita growth ($GDPpcg$) is the dependent variable in Equation (1). ODR represents the old dependency ratio, as the share of individuals aged 65 and over in the working-age population at ages 15 to 64. It is used as a proxy for population ageing. GCF represents the gross capital formation, as a measure of total investment in an economy. It increases production capacity and the potential for technological development, thus providing the basis for sustainable long-run economic growth. GS stands for the gross savings, which is calculated as the gross national income less total consumption, plus net transfers. Finally, LFP denotes the labor force participation rate, as a share of labor force (the sum of employed and unemployed persons) in the country's total population. *GCF, GS* and *LFP* represent the economic variables closely related to economic growth, so they are used as the control variables in the model.

In order to observe an additional measure of economic performance, we also include total GDP growth (*GDPg*) in the model as the dependent variable, as suggested by Hsu and Lo (2019), Ahmad and Ali Shah (2021) and Maestas, Mullen and Powell (2023). The advantage of including *GDPg* instead of the GDP per capita is that it is not directly affected by population growth, thus providing more valid results about the effects of population changes (including ageing) on economic growth. The regressors in the model with *GDPg* are the same as in Equation (1), except in the case of the labor force participation rate. Following Lee and Shin (2021), we multiply the data series for *LFP* rate with the total working-age population 15 years old and over (N^{15}) to obtain the total labor force ($LFP_{it}N_{it}^{15}$), which is then used as one of the regressors:

$$GDPg_{it} = a_i + b_1 ODR_{it} + b_2 GCF_{it} + b_3 GS_{it} + b_4 LFP_{it} N_{it}^{15} \quad (2)$$

We employ the Autoregressive Distributed Lag (ARDL)-class econometric model as a suitable cointegration method to generate long-run and short-run estimates and series analyses with a single cointegration vector (Topor et al., 2022). ARDL model in error correction form, with GDP per capita growth as a dependent variable, could be presented as follows (hereafter: Model 1):

$$\begin{aligned}\Delta GDPpcg_{it} = {} & \alpha_i + \beta_1 GDPpcg_{i,t-1} + \beta_2 ODR_{i,t-1} + \beta_3 GCF_{i,t-1} + \beta_4 GS_{i,t-1} \\ & + \beta_5 LFP_{i,t-1} \\ & + \sum_{j=1}^{p-1} \gamma_{ij} \Delta GDPpcg_{i,t-j} + \sum_{l=0}^{q-1} \delta_{il} \Delta ODR_{i,t-l} \\ & + \sum_{m=0}^{k-1} \theta_{im} \Delta GCF_{i,t-m} + \sum_{c=0}^{h-1} \mu_{ic} \Delta GS_{i,t-c} \\ & + \sum_{w=0}^{r-1} \varphi_{iw} \Delta LFP_{i,t-w} + \varepsilon_{it}\end{aligned} \quad (3)$$

where i = 1, 2, …, N and t = 1, 2, …, T; Δ is the first difference operator, α_i denotes the intercept, and ε_{it} is the error term. The long-run coefficients are denoted with $\beta_1 - \beta_5$, whereas γ, δ, θ, μ, and φ represent the short-run coefficients. In analogous way, the model with GDP growth can be formulated by replacing LFP_{it} with $LFP_{it}N_{it}^{15}$, as mentioned above (hereafter: Model 1).

In panel samples with individual effects, standard regression estimation of ARDL models presents a difficulty as a result of the bias generated by correlation between the mean-differenced regressors and the error term. This bias only disappears for large numbers of observations *T*, and is not possible to correct by increasing the number of cross-sections, *N*. One of the common approaches for dynamic data analysis is the Pooled Mean Group (PMG) estimator (Pesaran, Shin and Smith, 1999). This estimator uses the cointegration form of the ordinary ARDL model and then modifies it for a panel framework by allowing the intercepts, short-run coefficients, and cointegrating terms to vary over cross-sections (IHS, 2022). The long-established ARDL supporting structure presumes that the long-run cointegrating relationship represents a symmetric linear combination of regressors. Thus, the PMG model can be presented in sublimated form as in Equations (4 – 5):

$$\Delta y_{i,t} = \phi_i EC_{i,t} + \sum_{j=0}^{q-1} \Delta X_{i,t-j'} \beta_{i,j} + \sum_{j=1}^{p-1} \lambda_{i,j^*} \Delta y_{i,t-j} + \varepsilon_{i,t} \quad (4)$$

where

$$EC_{i,t} = y_{i,t-1} - X'_{i,t}\theta \quad (5)$$

$EC_{i,t}$ is the error correction term representing cointegrating relation. Hence, it is presumed that both the dependent variable, *y* (*GDPpcg*, or *GDPg* in Model 2), and the independent variables, represented by the vector *X* (the variables *ODR*, *GCF, GS, LFP*, or *LFPN*[15] in the Model 2) have the same number of lags in any cross-section. Even though it is not strictly required for the estimation, it is also convenient to presume that the regressors *X* should have the same number of lags *q* in any cross-section (Wooldridge, 2002; IHS, 2022). Thus, θ represents the long-run coefficients, ϕ_i stands for the adjustment coefficients. Furthermore, with *j-th* are defined the lags of ΔX and Δy, as ΔX_{i-j} and Δy_{i-j} respectively, and aditionally, $\beta_{i,j}$, λ_{i,j^*} and $\varepsilon_{i,t}$ represent the estimates of the coefficients and intercept, respectively.

The analysis was conducted by using data collected from the World Bank and UN databases (World Bank, 2022; UN, 2022) about 5 different time series: GDP (per capita) growth, annual percentage (*GDPpcg* or *GDPg*), old-age dependency ratio, percentage of working-age population (*ODR*), gross savings, percentage of GDP (*GS*), labor force participation rate, percentage of total population ages 15+ (*LFP*) and the gross capital formation, percentage of GDP (*GCF*). All the variables were transformed into a natural logarithm/differenced in their levels. This study focuses on the eight CEE countries – Latvia, Poland, Romania, Bulgaria, The Czech Republic, Hungary, Slovenia and Slovakia – in the period 2000 – 2020. In the period foregoing the COVID-19 pandemic year (2020), the average five-year percentage growth of annual GDP for these eight countries was 3.8% (World Bank, 2022). In addition, to test the robustness of the obtained estimates, we include the second group of advanced economies which consists of a panel of seven EU countries (Italy, Germany, Finland, Sweden, Greece, France, and Portugal) and the EU-27 average. These are the countries with the oldest population (based on the ODR indicator dynamics in the observed period), (Eurostat, 2024), and the relatively mature economies with relatively moderate economic growth rates. These facts recommend the mentioned countries as a representative control group to validate the empirical results for the emerging EU economies.

3. Empirical Results

Before continuing with the ARDL estimation, the orders of integration of the series were studied. The specification of the integration orders was performed by a cross-sectionally independent unit root test. The test was performed directly by the ADF-Fisher Chi-square and ADF-Choi Z-stat tests on the first difference of the series for each model, with intermediate ADF test for individual series (Table 1). The results show that all variables are stationary at the first differences, indicating that none of the variables is identified as I(2).

T a b l e 1

Unit Root Test Results (individual unit root process)

Method	**Model 1 – EE**	**Model 1 – AE**	**Model 2 – EE**	**Model 2 – AE**
	Statistic (p-value)[**]			
ADF-Fisher Chi-square	432.802 (0.0000)	411.700 (0.0000)	435.329 (0.0000)	*447.685 (0.0000)*
ADF Choi Z-stat	–19.9814 (0.0000)	–19.4119 (0.0000)	–20.052 (0.0000)	–20.3824 (0.0000)
Series	***Intermediate ADF test results (p-values)***			
ΔGCF	0.0000	0.0000	0.0000	0.0000
ΔGS	0.0000	0.0000	0.0000	0.0000
$\Delta GDPpcg$	0.0000	0.0000	–	–
$\Delta GDPg$	–	–	0.0000	0.0000
ΔLFP	0.0000	0.0000	–	–
$\Delta LFPN$[15]	–	–	0.0000	0.0000
ΔODR	0.0000	0.0000	0.0000	0.0000

Notes: Model 1 – dependent variable: *GDPpcg*; Model 2 – dependent variable: *GDPg*; EE – emerging EU economies; AE – advanced EU economies; Null Hypothesis: Unit root (individual unit root process); [**] Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution; all other tests assume asymptotic normality.

Source: Author's calculation.

In addition, the presence of the cointegration, i.e. the existence of the long-run relation among the variables under investigation, was tested by computing the Bounds F-statistic in order to establish a long run relationship (Table 2). Bounds tests for cointegration are robust to whether variables of interest are $I(0)$, *I*(1), or reciprocally cointegrated. These tests are performed as standard F-test or Wald tests of parameter significance in the cointegrating relationship of the conditional error correction model for each cross-section (Pesaran et al., 2001; Kollias et al., 2008) in both country groups.

In the framework being used, the mean F-bounds test statistics for the emerging economies are 5.31 and 8.15, and for advanced economies 11.05 and 12.37 for Models 1 and 2, respectively. All these values are beyond the I(1) critical value bound at 5% statistical significance level, confirming the presence of a cointegrating relationship. For both ARDL models for advanced EU countries, the Bounds F-statistic showed extremely higher bounds for France (29.5; 32.2, respectively), than the mean average for each model. For both ARDL models for the emerging EU countries, Slovenia (10.7; 21.5) and Latvia (9.8; 17.1) were two countries with quite higher Bounds F-statistic values when compared with the mean average.

T a b l e 2

Bounds Test for Cointegration

Emerging EU economies			**Advanced EU economies**		
Cross-section	***Model 1***	***Model 2***	***Cross-section***	***Model 1***	***Model 2***
	F-statistic	*F-statistic*		*F-statistic*	*F-statistic*
Poland	2.8219	2.6643	Italy	4.5489	5.4886
Slovenia	10.7398	21.5492	Germany	11.2552	18.8362
Bulgaria	3.8334	4.9845	Finland	3.8222	3.8521
Czech Republic	2.7156	1.7605	Sweden	6.5021	6.0941
Hungary	5.9255	5.3848	Greece	9.3613	8.9909
Romania	2.9121	6.0408	France	29.5597	32.1984
Slovakia	3.7737	5.6688	Portugal	11.8833	10.7783
Latvia	9.7921	17.1241	EU average	11.4459	12.7419
Mean F-stat.	5.3143	8.1471	Mean F-stat.	11.0473	12.3726

Notes: Null hypothesis: No levels relationship. Critical values are obtained from Pesaran et al. (2001) and Narayan (2005), Case II: Restricted intercept and no trend; 5% significance: I(0) = 3.100 (Narayan: 3.538) and I(1) = 3.870 (Narayan: 4.428).

Source: Authors' calculations.

The estimation results for both the long-run and short-run coefficients of the Model 1, for emerging CEE and advanced EU countries, are presented in Table 3. The obtained short-run coefficients are the mean of the cross-section specific coefficients. LFP and GS were specified as fixed or static regressors in the model.

Table 3 presents the ARDL (PMG) estimation into two parts. The first part shows the estimates of the long-run or pooled coefficients. The coefficient on the ODR is an estimate of the long-run old-age dependency elasticity, and is negative (and strongly significant) in both group of countries, as expected by economic theory. The coefficient values are –0.52 and –0.28 for emerging and advanced economies, respectively. The higher coefficient value in model with emerging countries could indicate that the population ageing has a more profound negative impact on the economic growth per capita in these economies in comparison with the advanced economies (which already have relatively older population).

T a b l e 3
Estimation Results for Model 1 (dependent variable: *GDPpcg*)

Variable	**Emerging EU economies PMG ARDL (1,1,1)**	**Advanced EU economies PMG ARDL (2,1,1)**
	Coefficient	*Coefficient*
Long-run (Pooled) Coefficients		
ODR	–0.5194***	–0.2769***
GCF	–0.1431	–0.4277***
Constant	19.2799*	–11.6513
Short-run (Mean-Group) Coefficients		
EC term	–0.7365***	–0.9409***
$\Delta GDPpcg_{-1}$	–	0.0089
ΔODR	0.9247**	0.6389
ΔGCF	1.0173***	1.6496***
GS	0.1894*	0.2898***
LFP	–0.0796	0.3918
Log-Likelihood	–332.8617	–264.3270
Jarque-Bera test	0.0636	1.9559

Note: ***, **, * denote significance at 1%, 5% and 10%, respectively.
Source: Authors' calculations.

The coefficient on the GCF (the estimate of the long-run gross capital formation elasticity) is also negative, but statistically significant only in the case of advanced economies. This result could be explained by the fact advanced economies rely more on investments in human capital than in physical capital to support economic growth per capita, as suggested by some empirical studies (for instance, Aksoy et al., 2019; Pham and Vo, 2021).

The second part of Table 3 covers the estimates for the mean-group short-run coefficients. The results suggest that ODR has statistically significant positive impact on GDP per capita in emerging economies, whereas GCF and GS have positive impact in both country groups. Therefore, in the short run, gross savings and capital formation are important factors in supporting economic per capita growth, while population ageing yet increases GDP per capita growth in emerging economies.

Furthermore, the estimates for cross-section-specific coefficients for each country are shown separately (Tables 1A and 2A in the Appendix). The results indicate that the Error correction (*EC*) term is negative and statistically significant in all emerging and advanced economies, except for Italy and the EU-27 average, confirming the convergence toward long-run equilibrium. The significance of particular regressors varies across the countries, with GCF as a dominant factor supporting short-run per capita growth, whereas ODR has a limited impact (it is significant and positive for Slovenia, France, and Finland, and negative for Sweden).

Analogously, Table 4 reports the results for Model 2. The long-run coefficients for ODR suggest that population ageing negatively affects total economic growth in both country groups, even though this impact is more pronounced in emerging countries (–0.53 compared with –0.42 in advanced economies). The long-run coefficient for GCF is negative for advanced economies whereas the short-run coefficient for emerging economies is positive. It indicates that the long-run growth in advanced economies is mainly supported by investing in human capital, whereas emerging economies should rely on investments in physical capital to increase short-run economic growth. In addition, total labor force represents the factor which negatively affects economic growth in emerging economies and positively in advanced economies in the short term. It could be explained by an intensive emigration from the emerging economies which induces labor force decline in the observed period ((Fihel and Okólski, 2019). This impact is also confirmed by the estimates for cross-section-specific coefficients for each country (Tables 3A and 4A in the Appendix).

T a b l e 4

Estimation Results for Model 2 (dependent variable: *GDPg*)

Variable	Emerging EU economies PMG ARDL (1,2,1)	Advanced EU economies PMG ARDL (2,1,1)
	Coefficient	*Coefficient*
Long-run (Pooled) Coefficients		
ODR	–0.5275***	–0.4199***
GCF	–0.0486	–0.2984***
Constant	105.7419	–20.0291
Short-run (Mean-Group) Coefficients		
EC term	–0.7907***	–0.9142***
$\Delta GDPg_{-1}$	–	–0.0254
ΔODR	1.4059**	0.7348***
ΔODR_{-1}	0.2659	–
ΔGCF	0.9761***	1.6525
GS	0.1206	0.2641
$lnLFPN$[15]	–4.9325***	0.5324***
Log-Likelihood	–296.9646	–263.6301
Jarque-Bera test	0.4140	1.7523

Note: ***, **, * denote significance at 1%, 5% and 10%, respectively.

Source: Authors' calculations.

The issue of finding the appropriate lag length for each of the underlying variables in the ARDL model is very important since the tendency is to have standard normal error terms that do not suffer from non-normality, autocorrelation, heteroskedasticity etc. The appropriate model of the long run equation was selected by determining the optimum lag length by using model order selection Akaike Information Criterion (AIC). In our case, the lag length is too short and then there may be some minimal serial correlation in errors. Using a panel cross-country growth regressions for short-run coefficients, time-series analysis finds that coefficient standard errors of all variables included are generally similar and lower than the coefficient standard errors of the ODR variable, which are generally upper in almost each country in both models.

T a b l e 5

Hausman Specification Test on the Similarity of PMG Estimator with MG Estimator

Model 1 (Emerging EU economies)				
Estimator		Stat.	DOF	p-value
Mean Group		0.3601	3	0.9484
Coefficient difference overview: Mean Group				
Variable	MG	PMG	Var(diff.)	p-value
ODR	**–0.5878**	**–0.5194**	**0.0751**	**0.8026**
GCF	**–0.0459**	**–0.1431**	**0.0323**	**0.5890**
C	**12.4853**	**19.2799**	**327.2488**	**0.7072**
Model 1 (Advanced EU economies)				
Estimator		Stat.	DOF	p-value
Mean Group		4.5214	3	0.2104
Coefficient difference overview: Mean Group				
Variable	MG	PMG	Var(diff.)	p-value
ODR	–0.1649	–0.2769	0.1263	0.7525
GCF	–0.5791	–0.4277	0.1248	0.6685
C	–161.9268	–11.6514	5794.0398	0.0484
Model 2 (Emerging EU economies)				
Estimator		Stat.	DOF	p-value
Mean Group		1.7512	3	0.6256
Coefficient difference overview: Mean Group				
Variable	MG	PMG	Var(diff.)	p-value
ODR	–1.3059	–0.5275	0.3725	0.2021
GCF	–0.1885	–0.0486	0.1567	0.7237
C	533.9104	105.7418	256338.1781	0.3977
Model 2 (Advanced EU economies)				
Estimator		Stat.	DOF	p-value
Mean Group		5.1143	3	0.1636
Coefficient difference overview: Mean Group				
Variable	MG	PMG	Var(diff.)	p-value
GCF	–0.5511	–0.4199	0.1276	0.7137
ODR	–0.2156	–0.2984	0.1481	0.8297
C	–158.1016	–20.0291	4920.7287	0.0490

Note: Null hypothesis: Estimator is statistically similar to the PMG estimator.

Source: Authors' calculations.

In order to check for the similarity of the PMG estimator to the mean-group estimator, we perform the Hausman test (Table 5). The results show that the null hypothesis is accepted and therefore the PMG estimator is selected as a better estimator than the MG estimator. It is more efficient as it generates coefficients of different short-run variation by country. On the other hand, for long term coefficients, it is assumed that all countries are homogeneous (similar).

4. Discussion of the Results and Sensitivity Analysis

The results of this study suggest that the increase in ODR will slow down the economic growth in emerging as well as in the advanced EU economies. The explanation for this relationship could be found in the fact the old population is less productive, which leads to slower GDP growth. In addition, the larger share of the elderly in the total population results in rising expenditures, such as health costs, directed to these categories of population. Bearing that the impact of the changes in ODR on economic growth is more profound in the emerging EU economies, the demographic structure in these countries should be more intensively monitored and regulated by the policy measures.

These findings are not surprising as many studies give special importance of the negative effect of the old-age dependency ratio on the GDP growth (Ahmad and Ali Shah, 2021; Cooley and Henriksen, 2018; Kelley and Schmidt, 2005; Hsu and Lo, 2019; Maestas et al., 2016; Lee and Shin, 2019). Thus, given the importance of old-age dependency for the GDP growth, as one of the most used indicator for the overall economy, besides unemployment (Ioannidis, et al., 2022), our findings seem to agree with the conclusions from demographic transition theory suggested by Jafrin et al. (2021), Börsch-Supan et al. (2019), Prskawetz et al. (2008), Bloom et al. (2015). Furthermore, alluding to the mechanism of demographic transition, Lueger (2018) emphasizes that during the transition from stagnation to growth in almost all modern economies, there is evidence of causality running from demographic to economic variables, which is also the case in our study.

The negative relationship that was found between ODR and GDP growth is due to the fact that all observed countries have recorded a larger percentage of the elderly population in their total population during this study period and still face this challenge (World Bank, 2022; Eurostat, 2023). Hence, the dynamics in population structures in emerging EU economies, as well as in the advanced ones, is a pressing issue, causing an imbalance in resources and population growth, which subsequently significantly affects economic growth. Furthermore, this negative impact of ODR suggests that it hinders the GDP growth in the long run, especially in emerging EU countries, but also that the GDP growth in these countries actually will benefit from a decrease in the old-age dependency ratio. On the other hand, the ODR reduction could result from changes in population dynamics as well as population structures. The practical solution to this situation is investing in human capital (e.g. Crespo Cuaresma et al., 2014), because a more educated and qualified population, and healthier as well, could increase the general level of productivity. In particular, GDP growth could benefit from policies that focus more on strategies with possible active and innovative approaches towards the older population and unemployed persons.

Furthermore, the results indicate that there is a statistically significant short-run impact of the labor force (LFPN[15]) on economic growth, which is negative in emerging EU economies and positive in advanced economies. This indicates that the promotion of structural changes that would reduce some of the legal constraints and encourage a longer period of work for older workers could increase economic growth in advanced EU economies. However, in emerging economies it is a consequence of intensive emigration, which means that the migration policy directed to the retention of the labor force should be implemented in order to support economic growth. Finally, the positive short-run effect of the rise in gross capital formation on the GDP (per capita) growth in both country groups presented in this study suggests that investments in physical capital represent the way to mitigate the slowing down the economic growth due to population ageing, as suggested in empirical studies (e.g. Calvo-Sotomayor et al., 2019; Poplawski-Ribeiro, 2020).

In this study, the ARDL method identified both long-term and short-term sensitivities, providing evidence on the sensitivity in the explanatory variables that can be a valuable tool in investigating trends in an economic growth, even in the presence of high variability of macroeconomic and/or macro level data. The common features of most cross-country economic growth regressions are that the explanatory variables are entered independently and linearly, where dependent variable is either per capita GDP growth or growth in GDP, and there are a set of variables always included in the regression, some of the variables are of interest as potentially important explanatory variables of economic growth.

A negative and robust long-run and short-run relationship was found between average economic growth rates and ODR for all four models. The coefficient of GCF does not remain significant in the long run for all models. In addition, the alterations in the conditioning information set change the statistical inferences that one draws regarding the GCF and economic growth relationship in models for emerging and advanced EU countries. Accordingly, the results concerning the long-term effect of GCF are considered fragile. In terms of the short-run statistical relationship between average economic growth rates and GS and ODR, results are sensitive to the coefficient does not remaining significant at 5% in the model with advanced economies. Also, in terms of the short-run statistical relationship between average economic growth rates and GS and LFP, results are sensitive to the coefficient does not remaining significant at 5% in the emerging EU economies model, except when total labor force (LFPN[15]) is used as a proxy variable but not LFP.

Furthermore, in the short-run cross country coefficients, cointegration equation for Italy and EU-27 average was found as not significant. Thus, the finding of a non-significant relationship between economic growth and the macroeconomic variables and the other variables at macro level for Italy and the EU-27 average, suggest that economic growth and per capita economic convergence may not operate primarily through fluctuations of the dependency ratio and increases in gross capital formation, domestic savings or labor force participation. Although there are many econometric specifications in which macroeconomic indicators taken individually or in groups are significantly related with economic growth, the cross-country statistical relationship between short-run average growth rates and almost every particular macroeconomic indicator is fragile. The results based on emerging/advanced economies data set also suggest that many cross-country growth findings are sensitive to the coefficient changes sign.

Conclusion with Policy Recommendations

Demographic factors, mainly related to population ageing, represent an important determinant of economic performance. Accordingly, the results presented in this study indicate the negative and statistically significant long-run impact of the ODR, as a measure of population ageing, and GDP growth, as a measure of economic activity, in observed emerging CEE economies and selected advanced EU economies. The empirical investigation showed that a one percent increase in ODR produces a 0.52 percent decrease in the long-run economic per capita growth in emerging CEE economies, compared with only a 0.28 percent decrease in advanced EU economies. Similar findings are obtained with GDP growth as a dependent variable (a 0.53 percent decrease in emerging countries versus a 0.42 percent decrease in advanced economies), confirming the robustness of the empirical results. These results indicate that emerging economies should closely monitor and regulate policy measures regarding demographic shifts associated with population ageing.

Furthermore, the rate of gross capital formation has a beneficial effect on short-term per capita economic growth in the majority of countries, while the influence of the gross savings and labor force participation rate on GDP growth varies among different groups of countries. In contrast, the total labor force variable has a positive short-run impact on economic growth in advanced and a negative impact on emerging EU economies.

The empirical findings in this study have important policy implications. The evident increase in longevity represents a positive trend, especially in CEE countries with lower life expectancy than in advanced EU countries. However, rising longevity, together with lower fertility results in a shrinking working-age population, thus eroding the tax base and jeopardizing fiscal stability. The decline of the working-age population will accelerate in observed countries as the baby boom generation continues to retire in the next decade. Therefore, policymakers should provide proper fiscal buffers in good economic conditions in order to implement countercyclical fiscal policy and to implement growth-enhancing structural reforms. This measure could also address the constraints in monetary policy connected to the effective lower bound in nominal interest rate, which was a very profound problem during the COVID-19 pandemic. However, providing a proper fiscal space and debt sustainability can be challenging taking into account the higher ageing-related public spending costs.

The stability of the public pension systems in emerging EU countries could be achieved by extending working life and by postponing retirement. These measures should be implemented together with the older workers productivity-enhancing policies, such as active ageing and lifelong learning. In addition, the investments in physical and especially in human capital could support sustainable economic growth. Some of the policy measures to this end could include the promotion of innovation and labor-saving technological progress.

Another challenge for labor market policies in emerging EU countries is related to the integration of more vulnerable categories in the labor market, such as youth, mothers, older workers, and people with disabilities. The results of this study suggest that the active labor policy measures should be especially tailored to older workers to support their employability, and to other categories, such as youth and women, to increase their participation in the labor market.

The governments in the emerging CEE countries also should address the problem of excessive migration, since it represents the main factor of population decline, together with the natural population change. The migration could be reduced by implementing incentives to prevent the youth population from leaving the country and by improving employment opportunities. Additionally, the measures to encourage the immigration of workers in these countries, such as the incentives for ensuring the integration of immigrants into the labor market, could help in mitigating the labor force shrinkage and promote economic growth.

References

ACEMOGLU, D. – RESTREPO, P. (2017): Secular Stagnation? The Effect of Aging on Economic Growth in the Age of Automation. American Economic Review: Papers and Proceedings, *107*, No. 5, pp. 174 – 179.

ACEMOGLU, D. – RESTREPO, P. (2022): Demographics and Automation. The Review of Economic Studies, *89*, No. 1, pp. 1 – 44. Available at: <https://doi.org/10.1093/restud/rdab031>.

AFOLABI, J. A. (2023): Employment Effects of Technological Innovation: Evidence from Nigeria's Economic Sectors. Economic Horizons, *25*, No. 1, pp. 3 – 17. DOI: 10.5937/ekonhor2301003A.

AHMAD, D. – ALI SHAH, S. Z. (2021): Impact of Dependency Ratio on Economic Growth among Most Populated Asian Countries. Journal of Development and Social Sciences, *2*, No. 4, pp. 563 – 579. Available at: <http://doi.org/10.47205/jdss.2021(2-IV)47>.

AKSOY, Y. – BASSO, H. S. – SMITH, R. P. – GRASL, T. (2019): Demographic Structure and Macroeconomic Trends. American Economic Journal: Macroeconomics, *11*, No. 1, pp. 193 – 222. DOI: 10.1257/mac.20170114.

ANDREI, E. A. – HUIDUMAC-PETRESCU, C. E. (2013): Saving and Economic Growth: An Empirical Analysis for Euro Area Countries. Theoretical and Applied Economics, *20*, pp. 43 – 58.

ANDRIULIS, V. – BUTKUS, M. – MATUZEVIČIŪTĖ, K. (2022): Will EU Be Less Productive in the Times of Aging Population? Intellectual Economics, *16*, No. 1, pp. 117 – 133. DOI: 10.13165/IE-22-16-1-07.

BARSUKOV, V. N. (2019): From the Demographic Dividend to Population Ageing: World Trends in the System-Wide Transition. Economic and Social Changes: Facts, Trends, Forecast, *12*, No. 4, pp. 167 – 182. DOI: 10.15838/esc.2019.4.64.11.

BIDISHA, S. H. – ABDULLAH, S. M. – SIDDIQUA, S. – ISLAM, M. M. (2020): How Does Dependency Ratio Affect Economic Growth in the Long Run? Evidence from Selected Asian Countries. The Journal of Developing Areas*,* *54*, No. 2, pp. 47 – 60.

BLOOM, D. E. – WILLIAMSON, J. G. (1998): Demographic Transitions and Economic Miracles in Emerging Asia. World Bank Economic Review, *12*, pp. 419 – 455.

BLOOM, D. E. – CANNING, D. – FINK, G. – FINLAY, J. E. (2009): Fertility, Female Labor Force Participation, and the Demographic Dividend. Journal of Economic Growth, *14*, pp. 79 – 101.

BLOOM, D. E. – CHATTERJI, S. – KOWAL, P. – LLOYD-SHERLOCK, P. – McKEE, M. – RECHEL, B. – ROSENBERG, L. – SMITH, J. P. (2015): Macroeconomic Implications of Population Ageing and Selected Policy Responses. Lancet, *385*, No. 9968, pp. 649 – 657. DOI: 10.1016/S0140-6736(14)61464-1.

BOATENG, E. – AGBOLA, F. W. – MAHMOOD, A. (2019): Does the Quality of Institutions Enhance Savings? The Case of Sub-Saharan Africa. Applied Economics, *51*, No. 58, pp. 6235 – 6263.

BÖRSCH-SUPAN, A. – LEITE, D. N. – RAUSCH, J. (2019): Demographic Changes, Migration and Economic Growth in the Euro Area. 20 years of European Economic and Monetary Union, Conference Proceedings, European Central Bank Forum on Central Banking, pp. 193 – 230.

CALVO-SOTOMAYOR, I. – LAKA, J. P. – AGUADO, R. (2019): Workforce Ageing and Labour Productivity in Europe. Sustainability, *11*, No. 20, pp. 5851. DOI: 10.3390/su11205851.

COOLEY, T. – HENRIKSEN, E. (2018): The Demographic Deficit. Journal of Monetary Economics, *93*, pp. 45 – 62.

CRESPO CUARESMA, J. – LUTZ, W. – SANDERSON, W. (2014): Is the Demographic Dividend and Education Dividend? Demography, *51*, No. 1, pp. 299 – 315.

EUROSTAT (2020): Ageing Europe – Looking at the Lives of Older People in the EU. Brussel/ Luxembourg: European Commission.

EUROSTAT (2023): Main Population Indicators: Proportion of Population Aged 65 and over. [Accessed on 2023 March 19.] Available at: <https://ec.europa.eu/eurostat/databrowser/view/tps00028/default/table?lang=en>.

EUROSTAT (2024): Projected Old-Age Dependency Ratio. [Online data code: proj_23ndbi.]

FIHEL, A. – OKÓLSKI, M. (2019): Population Decline in the Post-Communist Countries of the European Union. Population and Societies*, 6*, No. 567, pp. 1 – 4.

HAQUE, A. U. – KIBRIA, G. – SELIM, M. L. – SMRITY, D. Y. (2019): Labor Force Participation Rate and Economic Growth: Observations for Bangladesh. International Journal of Economics and Financial Research, *5*, No. 9, pp. 209 – 213.

HEADY, D. D. – HODGE, A. (2009): The Effect of Population Growth on Economic Growth: A Meta-Regression Analysis of the Macroeconomic Literature. Population and Development Review, *35*, pp. 221 – 248.

HSU, Y. H. – LO, H. C. (2019): The Impacts of Population Aging on Saving, Capital Formation, and Economic Growth. American Journal of Industrial and Business Management, *9*, pp. 2231 – 2249.

HUANG, T. – XIE, Z. (2013): Population and Economic Growth: A Simultaneous Equation Perspective. Applied Economics, *45*, pp. 3820 – 3826.

IHS GLOBAL Inc. (2022): EViews 13 User's Guide II. Seal Beach, CA: IHS Global Inc.

IOANNIDIS, E. – TSOUMARIS, D. – NTEMKAS, D. – SARIKEISOGLOU, I. (2022): Correlations of ESG Ratings: A Signed Weighted Network Analysis. AppliedMath, *2*, pp. 638 – 658. Available at: <https://doi.org/10.3390/ appliedmath2040037>.

JAFRIN, N. – MAHI, M. – MASUD, M. M. – GHOSH, D. (2021): Demographic Dividend and Economic Growth in Emerging Economies: Fresh Evidence from the SAARC Countries. International Journal of Social Economics*, 48*, No. 8, pp. 1159 – 1174.

KELLEY, A. C. – SCHMIDT, R. M. (2005): Evolution of Recent Economic-Demographic Modeling: A Synthesis. Journal of Population Economics, *18*, pp. 275 – 300.

KOLLIAS, C. – MYLONIDIS, N. – PALEOLOGOU, S. M. (2008): The Feldstein – Horioka Puzzle Across EU Members: Evidence from the ARDL Bounds Approach and Panel Data. International Review of Economics and Finance, *17*, pp. 380 – 387.

KOPECKY, K. A. (2011): The Trend in Retirement. International Economic Review, *52*, No. 2, pp. 287 – 316. DOI: 10.1111/j.1468-2354.2011.00629.x.

KREMER, M. (1993): Population Growth and Technological Change: One Million B.C. to 1990. Quarterly Journal of Economics, *108*, pp. 681 – 716.

KUZNETS, S. (1960): Population Change and Aggregate Output. In: ROBERTS, G. (ed.): Demographic and Economic Change in Developed Countries. National Bureau of Economic Research, pp. 324 – 351.

LEE, H. – SHIN, K. (2019): Nonlinear Effects of Population Aging on Economic Growth. Japan and the World Economy, *51*, September, 100963.

LEE, H. – SHIN, K. (2021): Decomposing Effects of Population Aging on Economic Growth in OECD Countries. Asian Economic Papers, *20*, No. 3, pp. 138 – 159.
DOI: 10.1162/asep_a_00839.

LEE, J. W. – SONG, E. (2020): Aging Labor, ICT Capital, and Productivity in Japan and Korea. Journal of the Japanese and International Economies, *58*, 101095. Available at:
<https://doi.org/10.2139/ssrn.3518875>.

LEE, R. D. – MASON, A. (2011): Population Aging and the Generational Economy: A Global Perspective. Cheltenham, UK and Northampton, US: Edward Elgar.

LEE, R. – MASON, A. (2006): What is the Demographic Dividend? Finance and Development. September. Washington, DC: International Monetary Fund.

LUEGER, T. (2018): A VAR Evaluation of Classical Growth Theory. Proceedings of the IISES Annual Conference, 05 March 2018, Sevilla, Spain. DOI: 10.20472/IAC.2018.035.030.

MAESTAS, N. – MULLEN, K. J. – POWELL, D. (2023): The Effects of Population Aging on Economic Growth, the Labor Force and Productivity. American Economic Journal: Macroeconomics, *15*, No. 2, pp. 306 – 332.

MALTHUS, T. R. (1826): An Essay on the Principle of Population. 6th edition. London: John Murray.

MANKIW, N. G. – ROMER, D. – WEIL, D. N. (1992): A Contribution to the Empirics of Economic Growth. Quarterly Journal of Economics, *107,* pp. 407 – 437.

MASON, A. – LEE, R. (2013): Labor and Consumption across the Lifecycle. The Journal of the Economics of Ageing, *1 – 2*, pp. 16 – 27. DOI: 10.1016/j.jeoa.2013.06.002.

MIERAU, J. O. – TURNOVSKY, S. J. (2014): Demography, Growth and Inequality. Economic Theory, *55*, pp. 29 – 68.

MODIGLIANI, F. – BRUMBERG, R. H. (1954): Utility Analysis and the Consumption Function: An Interpretation of Cross-Section Data. In: KURIHARA, K. K. (ed.): PostKeynesian Economics. New Brunswick, NJ: Rutgers University Press, pp. 388 – 436.

NAGARAJAN, N. R. – TEIXEIRA, A. A. C. – SILVA, S. T. (2016): The Impact of an Ageing Population on Economic Growth: An Exploratory Review of the Main Mechanisms. Análise Social, *51*, No. 216, pp. 4 – 35.

NARAYAN, P. K. (2005) The Saving and Investment Nexus for China: Evidence from Cointegration Tests. Applied Economics, *37*, No. 17, pp. 1979 – 1990.
DOI: 10.1080/00036840500278103.

PESARAN, M. H. – SHIN, Y. – SMITH, R. P. (1999): Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. Journal of the American Statistical Association, *94*, No. 446, pp. 621 – 634. Available at: <https://doi.org/10.1080/01621459.1999.10474156>.

PESARAN, M. H. – SHIN, Y. – SMITH, R. J. (2001): Bounds Testing Approaches to the Analysis of Level Relationships. Journal of Applied Econometrics, *16*, No. 3, pp. 289 – 326.

PETERSON, E. W. F. (2017): The Role of Population in Economic Growth. SAGE Open, *7*, No. 4. Available at: <https://doi.org/10.1177/2158244017736094>.

PHAM, T. N. – VO, D. H. (2021): Aging Population and Economic Growth in Developing Countries: A Quantile Regression Approach. Emerging Markets Finance and Trade, *57*, No. 1, pp. 108 – 122.

POPLAWSKI-RIBEIRO, M. (2020): Labour Force Ageing and Productivity Growth. Applied Economics Letters, *27*, No. 6, pp. 498 – 502. DOI: 10.1080/13504851.2019.1637509.

PRSKAWETZ, A. – BLOOM, D. E. – LUTZ, W. (eds) (2008): Population Aging, Human Capital Accumulation, and Productivity Growth. A Supplement to Vol. 34 of the Population and Development Review. New York: Population Council.

SHAHID, M. (2014): Impact of Labour Force Participation on Economic Growth in Pakistan. Journal of Economics and Sustainable Development, *5*, No. 11, pp. 89 – 93.

SOLOW, R. M. (1956): A Contribution to the Theory of Economic Growth. Quarterly Journal of Economics, *70*, No. 1, pp. 65 – 94.

TÁLAS, P. – ETL, A. (eds) (2020): Demography and Migration in Central and Eastern Europe. Budapest: Dialóg Campus.

TOPOR, D. I. – MARIN-PANTELESCU, A. – SOCOL, A. – IVAN, O. R. (2022): Decarbonization of the Romanian Economy: An ARDL and KRLS Approach of Ecological Footprint. Amfiteatru Economic, *24*, No. 61, pp. 664 – 682. DOI: 10.24818/EA/2022/61/664.

UDDIN, G. A. – ALAM, K. – GOW, J. (2016): Population Age Structure and Savings Rate Impacts on Economic Growth: Evidence from Australia. Economic Analysis and Policy, *52*, pp. 23 – 33. Available at: <https://doi.org/10.1016/j.eap.2016.08.002>.

UNITED NATIONS (2022): GDP Growth – GDP Annual Growth Rate. United Nations Statistics Division, System of National Accounts. [Retrieved data latest on 2022 Oct 12.] Available at: <https://unstats.un.org/unsd/snaama/Basic>.

WOOLDRIDGE, J. M. (2002): Econometric Analysis of Cross Section and Panel Data. Cambridge, MA: The MIT Press.

WORLD BANK (2022): World Bank Development Indicators. Available at:
<https://data.worldbank.org/indicator>.

Appendix

Table A1

Error Correction Regression Results for the Model 1 – Emerging EU Economies

Variable	Poland	Slovenia	Bulgaria	Czech R.	Hungary	Romania	Slovakia	Latvia
EC term	–0.5985**	–1.0846***	–0.9279***	–0.6586***	–0.6300***	–0.7039***	–0.7575***	–0.5313***
ΔODR	0.6726	2.9516***	–1.4819	0.9609	1.3232	1.7987	0.3186	0.8540
ΔGCF	0.8139***	0.8236***	0.6579**	1.6281***	1.3145***	1.3750***	0.5372	0.9884***
GS	0.2577	0.6544**	0.0030	0.0465	–0.1325	0.1132	0.6767	–0.1035
LFP	–0.1035	–0.3214**	0.0541	–0.0301	0.0354	–0.0445	–0.2850	0.0584

Note: ***, **, * denote significance at 1%, 5% and 10%, respectively.

Source: Authors' calculations.

Table A2

Error Correction Regression Results for the Model 1 – Advanced EU Economies

Variable	Italy	Germany	Finland	Sweden	Greece	France	Portugal	EU-27
EC term	–0.5045	–0.9527***	–0.7072***	–1.1589***	–0.6796***	–1.7811***	–1.0549**	–0.6886
$\Delta GDPpcg_{-1}$	–0.0667	0.1953	–0.3413*	0.1086	–0.0329	0.1774	0.1383	–0.1078
ΔODR	0.4405	–0.4681	6.1651*	–2.3403*	0.0111	5.4541***	–2.5246	–1.6266
ΔGCF	2.7291***	1.9079***	2.0096***	1.8889***	0.1572	0.8393**	1.2907***	2.3739***
GS	–0.9895	–0.3284	0.5622	–0.3199	1.1684***	2.5179***	0.1869	–0.4792
LFP	0.6876***	0.6301***	0.0438	0.7131***	0.1114*	–0.1053	0.4847**	0.5691**

Note: ***, **, * denote significance at 1%, 5% and 10%, respectively.

Source: Authors' calculations.

T a b l e A3

Error Correction Regression Results for the Model 2 – Emerging EU Economies

Variable	Poland	Slovenia	Bulgaria	Czech R.	Hungary	Romania	Slovakia	Latvia
EC term	–0.5915**	–1.2758***	–0.9639***	–0.5500**	–0.7069***	–0.8426***	–0.8526***	–0.5426***
ΔODR	0.5078	4.3392***	–1.4055	2.2954	2.2319	2.8095	0.4556	0.0133
ΔODR_{-1}	0.3608	2.7173***	0.4335	–1.7102	0.2005	2.4160	–0.1016	–2.1891
ΔGCF	0.7657***	0.7635***	0.6903***	1.4382***	1.4342***	1.3044**	0.5461	0.8659***
GS	0.1632	0.7225***	0.0238	0.0144	–0.1511	–0.0354	0.8098*	–0.5828*
$lnLFPN^{15}$	–3.3775*	–9.7855***	–5.5598***	–3.2011	–4.0011***	–4.7326***	–6.4499***	–2.3525***

Note: ***, **, * denote significance at 1%, 5% and 10%, respectively.

Source: Authors' calculations.

T a b l e A4

Error Correction Regression Results for the Model 2 – Advanced EU Economies

Variable	Italy	Germany	Finland	Sweden	Greece	France	Portugal	EU-27
EC term	–0.4831	–1.0127**	–0.7033***	–1.1119***	–0.6471***	–1.7251***	–1.0474**	–0.5834
$\Delta GDPg_{-1}$	–0.0783	0.1003	–0.3481*	0.0728	–0.0468	0.1495	0.1262	–0.1804
ΔODR	0.5996	0.2908	6.2664*	–1.7735	–0.0003	4.9691***	–3.0784	–1.3955
ΔGCF	2.7097***	1.6516***	2.0297***	1.9656***	0.1636	0.8857***	1.3093**	2.5043***
GS	–1.0914	–0.1432	0.5311	–0.3734*	1.1445***	2.4771***	0.2497	–0.6817
$lnLFPN^{15}$	0.8038***	0.7223***	0.1607	0.8786***	0.2086**	0.1727*	0.6236**	0.6885***

Note: ***, **, * denote significance at 1%, 5% and 10%, respectively.

Source: Authors' calculations.