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Impact of population ageing on fiscal balance in the European Union

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ABSTRACT

In the past two decades, the EU has experienced low fertility rates and declining mortality rates leading to population ageing. Although increasing immigration and longer life expectancy reinforced population growth, these trends could not counterbalance the negative impact of low birth rates on labour supply. Demographic transition towards an aging society is characterised by increase of public health and pension expenditures, as well as decrease of tax revenues that are triggers for fiscal imbalance. The paper aims to analyse the effects of population ageing on government fiscal balance in the EU-27 by applying modern methods of panel data analysis in the period 2001–2021. The dependent variable is general government fiscal balance, while the explanatory variables are related to demographic transition indicators (population aged over 64 in total population, old-age dependency ratio, and health expenditures) and macroeconomic control variables. The results of research show that population ageing has created a significant negative impact on fiscal balance of the EU countries, which was confirmed by all the analysed models. The fixed-effects panel threshold model did not identify a statistically significant threshold of any demographic transition indicator, concluding that population ageing has equally negatively affected fiscal balance, independent of the values of demographic transition indicators.

KEYWORDS

fiscal balance, population ageing, government expenditures, health expenditures, European Union

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1 INTRODUCTION

Population ageing is a worldwide phenomenon that has an increasing trend. Older population (people 65 years of age or older) is growing globally, both in absolute numbers and as a share of the total population. Compared to 1980 the number of older people tripled and it is expected to be additionally doubled until 2050 (UN 2023). According to UN projections (United Nations 2022), the share of older population in the total population will have increased from 10% in 2022 to 16% in 2050. Even though, population ageing is faster in developed economies. According to 2022 data, while the share of older population in the total population on the global level was 10%, it was as high as 19% in the group of high income countries (World Bank database 2024). The problem of ageing population is most pronounced in Japan (30%), followed by the European Union member countries where the average share of older people is 21% (above the European Union average are Italy 24%, Greece, Finland and Portugal 23%, France, Germany, Latvia, Bulgaria and Croatia 22%).

Key drivers of population ageing in the European Union are declining fertility and increasing longevity. We had witnessed a long-term declining trend in the fertility rates since the mid-1960s, while at the beginning of 2000s the fertility rates showed signs of recovery. During the 2001–2021 period, the fertility rate increased by 8%, while the highest rise was recorded in Czech Republic (59%), followed by Romania (43%) and Slovakia and Slovenia (both 36%). Conversely, Malta (24%), Finland (16%) and Portugal (7%) recorded the highest decrease of fertility rates. The latest data for 2022 showed that the total fertility rate in the EU was 1.46 live births per woman, ranging from 1.08 in Malta to 1.79 in France (Eurostat 2024). On the other hand, statistics indicates that life expectancy has risen, on average, by more than two years per decade since the 1960s, mainly driven by improvements in healthcare and medicine and socio-economic progress (Raleigh 2019; Poças, Soukiazis and Antunes 2020).

Population ageing puts pressure on government policies and becomes a serious challenge to fiscal balance (Temsumrit 2023). The main effects are referred to be shrinking working population (who are taxpayers) and increasing age-related expenditures such as pensions, healthcare, long-term care and education (Pinkus and Ruer 2024). In order to assess the long-term sustainability of public finances and provide coordination among public policies in the European Union, the European Commission prepared projections that show how ageing expenditures might develop in the period up to 2070. It is expected that the old-age dependency ratio (the number of older persons divided by the number of working-age people 20 to 64 years) will increase from 36% in 2022 to 59% in 2070, while the ageing expenditures will rise by 1.2 percentage points of GDP by 2070 (European Commission 2024). The ageing expenditures already had the share of 24.4% of the gross domestic product (GDP) in 2022 (including 11.4% for pensions, 6.9% for health care, 4.4% for education and 1.7% for long-term care), while further decline in the working-age population would diminish tax revenues.

This trend will erode the tax base for personal income taxes and social security contributions (Bodnár and Nerlich 2022), while compensating public revenues, through higher tax rates,

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may cause distortions, risks and negative effects (Crowe et al. 2022). On the other hand, in the absence of social security reforms, countries will face the problem of long-term fiscal sustainability (Ramos-Herrera and Sosvilla-Rivero 2020). Even though, there are only limited empirical studies analysing population effects on public debt (Cho and Rhee 2023; Kopecky 2022; Afflatet 2018), it seems that high debt countries are more exposed to the risk of fiscal unsustainability.

In expert discussions, immigration often appears as a solution to the fiscal burden of aging. There are empirical studies that show positive implications of immigration flows on the European Union budget (Bernardinoa, Francob and Morais 2024; Fiorio et al. 2024; Christl et al. 2022), however, immigration alone cannot solve the fiscal burden of aging. Even though migration inflows in the EU have been significant over the last five decades and have had a positive impact on employment (Noja et al. 2018), net migration flows will not offset the ageing trend in the population (European Commission 2021). What is more, their total impact depends on many a factor (Ortega-Gil, ElHichou-Ahmed and Mata-García 2022; OECD 2013) including education and age structure, employment status, etc., demonstrating that the immigrant flows' impact on unemployment rate is very weak.

Taking into account the scale and complexity of the problem, as well as the need for an urgent response by policy makers, it is essential to provide empirical evidence that will be a base for adequate policy measures. One of the key steps is to develop an adequate model and quantify the fiscal impact of demographic changes (Amaglobeli and Wei 2016), however, there is limited number of empirical research studies that analyse the overall effects of population aging on long-term fiscal balance.

Recognizing that this topic is of great interest and volatility, the authors of this paper made an effort to address the effects of population ageing on the fiscal balance of the European Union member states. The remainder of this paper is organized as follows. Section 2 of this paper introduce procedures and techniques of panel data analysis, as well as model specification, data and sample that are used in the empirical research. The results of the research are presented in section 3, while discussion is elaborated in the section 4. Finally, concluding remarks are presented in section 5.

2 METHOD

2.1 PROCEDURES AND TECHNIQUES OF PANEL DATA ANALYSIS

The initial main hypothesis of the paper claims that population ageing negatively affects fiscal balance and increases budget deficit. In order to test the stated hypothesis, econometric methods of panel data analysis will be applied. Panel data represent a combination of cross-section and time-series data. This means that all the variables in the panel data models involve two dimensions, spatial and temporal. The spatial dimension indicates that observations vary across units, in macro panels usually across countries, and the temporal dimension implies that observations change over time. Baltagi (2008) emphasised numerous benefits from using panel data, including controlling for individual heterogeneity, more informative data, less collinearity among the variables, more variability, more degrees of freedom and more efficiency.

According to Jovičić and Dragutinović Mitrović (2011), the common procedure of panel data analysis starts with the estimation of the pooled model with constant regression parameters of the following form:

$$y_{it} = \beta_1 + \sum_{k=2}^{K} \beta_k x_{kit} + u_{it} \quad (1)$$

With y_{it} denoting dependent variable, i units (countries), t time (years), X_{kit} k independent variables, β_1 constant term, β_k k regression parameters, and u_{it} disturbance. In this model, all regression parameters are constant, and disturbance includes all variations by units and over time.

In the second step, the estimation of the fixed-effects model with individual effects of the following form should be carried out:

$$y_{it} = \beta_{1i} + \sum_{k=2}^{K} \beta_k x_{kit} + u_{it} \quad (2)$$

Where β_{1i} represents a coefficient, which varies across countries and equals:

$$\beta_{1i} = \beta_1 + \mu_i \quad (3)$$

With μ_i denoting unobservable time-invariant individual effects.

Finally, the random-effects model of the following form is also to be considered:

$$y_{it} = \beta_1 + \sum_{k=2}^{K} \beta_k x_{kit} + u_{it} \quad (4)$$

Where u_{it} equals:

$$u_{it} = \mu_i + v_{it} \quad (5)$$

With μ_i denoting unobservable time-invariant individual effects as an error component, and v_{it} remainder disturbance.

In order to choose the appropriate model and estimation method, the following econometric tests should be conducted: testing for individual effects, testing for heteroscedasticity, testing for serial correlation, specification tests and unit-root tests.

Testing for individual effects can be done by the F-test in the fixed-effects model (Baltagi 2008), and the Breusch-Pagan LM test in the random-effects model (Breusch and Pagan 1980). If individual effects are detected, the choice between the fixed and the random model specification should be made by using the Hausman's specification test (Jovičić and Dragutinović Mitrović 2011).

Heteroscedasticity can be tested by the White test in the pooled model (White 1980), the modified Wald test in the fixed-effects model (Greene 2003) and the Breusch-Pagan LM test in the random-effects model. Testing for serial correlation can be carried out by the Wooldridge test in the pooled model (Wooldridge 2010), the BFN-DW test in the fixed-effects model (Bhargava, Franzini and Narendranathan 1982) and the Baltagi-Li test in the random-effects model (Baltagi and Li 1991). If heteroscedasticity and serial correlation are present, the model with standard errors robust to violation of assumptions related to homoscedasticity and absence of serial correlation should be estimated (Arellano 1987).

Baltagi (2008) listed various unit-root tests which could be applied to panel data, such as Levin-Lin-Chu test, Im-Pesaran-Shin test, Breitung's test, combining p-value tests, residual-based LM tests, Pesaran CADF and CIPS test, etc. Stationarity of the panel data in this paper will be tested by Fisher-type ADF test proposed by Choi (2001). Only stationary

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variables should be included in the final version of any model. If some variable has a unit root, than the raw data should be transformed by differencing and only its stationary differences should be used (Mladenović and Nojković 2018).

Beside the initial main hypothesis about the negative effect of population ageing on fiscal balance, the research should also check for potential structural break, or jumping character in the relation between population ageing and fiscal balance, by using the fixed-effects panel threshold model of the following form:

$$y_{it} = \begin{cases} \beta_1 + \sum_{k=2}^{K} \beta_k X_{kit} + a_1 q_{it} + \mu_i + u_{it}, \; if \; q_{it} \leq \gamma \\ \beta_1 + \sum_{k=2}^{K} \beta_k X_{kit} + a_2 q_{it} + \mu_i + u_{it}, \; if \; q_{it} > \gamma \end{cases} \quad (6)$$

With q_{it} denoting threshold variable and γ denoting threshold parameter, that divides the regression equation into two regimes with coefficients a_1 and a_2 (Hansen 1999).

2.2 MODEL SPECIFICATION, DATA AND SAMPLE

The dependent variable in this research is fiscal balance measured by percentage of GDP. The independent variables explaining population ageing and demographic transition include the old-age dependency ratio measured by the ratio of people older than 64 to the working-age population, the share of population older than 64 in total population, as well as health expenditures as an implicit proxy of demographic transition measured by percentage of GDP.

The independent macroeconomic control variables include real GDP growth rate expressed in percentage change, government revenue measured by its share in GDP, unemployment rate measured by the share of the unemployed in the total labour force, and trade openness measured by the share of exports and imports of goods and services in GDP. Table 1 provides description of all variables and used data sources.

Table 1 Description of variables and data sources

Variable name	Description	Abbreviation	Source
Dependent variable:			
Fiscal balance	Fiscal balance as % of GDP	balance	EUROSTAT database
Independent variables explaining population ageing:			
Old-age dependency	Population aged 65+ as % of working-age population	agedep	EUROSTAT database
Share of people aged 65+ in total population	Population aged 65+ as % of total population	share65	EUROSTAT database
Health expenditures	Government health expenditures as % of GDP	health	EUROSTAT database
Independent macroeconomic control variables:			
GDP growth rate	Annual real GDP growth rate in %	growth	IMF WEO database
Government revenue	Government revenue as % of GDP	revenue	EUROSTAT database
Unemployment rate	Share of the unemployed in total labour force	unemploy	IMF database
Trade openness	Share of exports and imports in GDP in %	trade	World Bank database

Source: Authors' research.

Table 2 Descriptive statistics

Variable name	Observations	Mean	Standard deviation	Minimum	Maximum
Dependent variable:					
Fiscal balance	567	-2.63	3.57	-32.1	5.6
Independent variables explaining population ageing:					
Old-age dependency	567	25.65	4.67	15.65	37.02
Share of people aged 65+ in total population	567	17.08	6.72	10.78	23.53
Health expenditures	567	6.12	1.44	2.5	10.1
Independent macroeconomic control variables:					
GDP growth rate	567	2.33	3.91	-14.84	24.48
Government revenue	567	42.41	6.39	22.2	56.4
Unemployment rate	567	8.78	4.42	1.89	27.48
Trade openness	567	120.88	64.23	45.42	393.14

Source: Authors' calculations.

The research will be carried out on a sample including 567 panel observations. The sample covers 27 countries of the European Union: Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, and Sweden. The covered period includes 21 years, from 2001 until 2021. Table 2 provides descriptive statistics for all variables.

Indicators of population ageing have changed significantly during the observed period in almost all countries. Figure 1 shows the values of the old-age dependency ratio in 2021 in EU countries, as well as the changes that have occurred in the last 20 years. For most

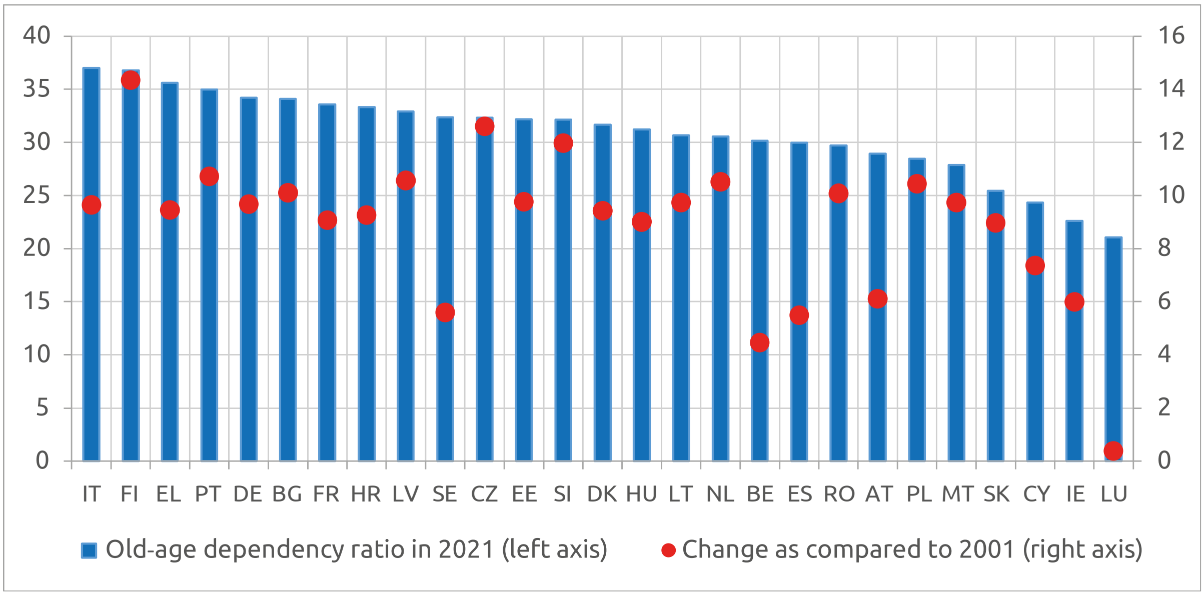

Figure 1 Old-age dependency ratio in 2021 by countries and its change as compared to 2001
Source: Authors' work based on Eurostat database (2024).

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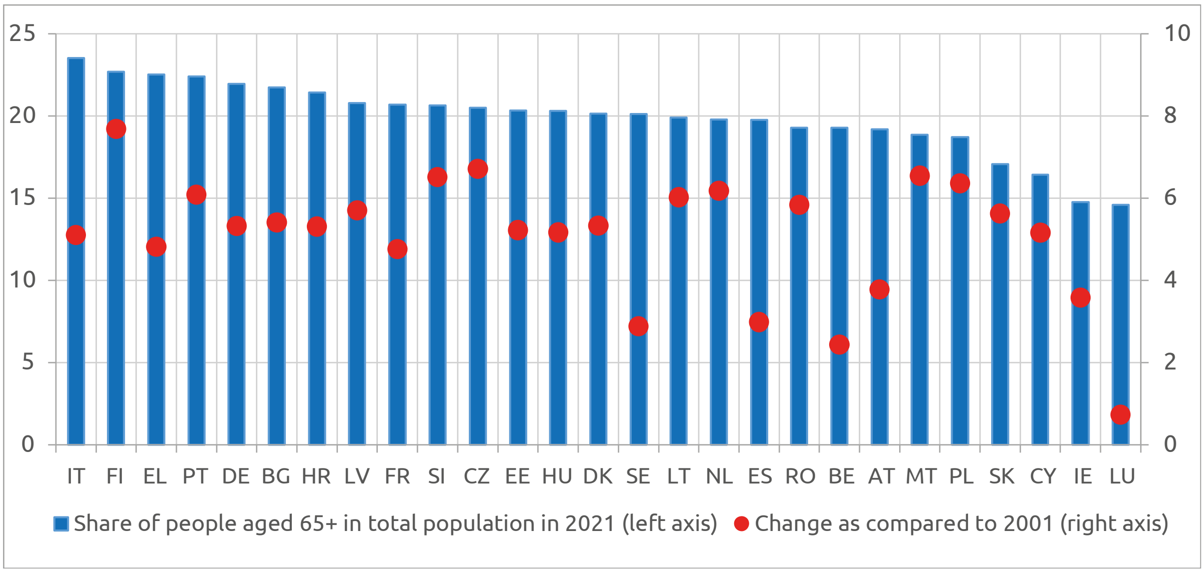

Figure 2 Share of people aged 65+ in total population in 2021 by countries and its change as compared to 2001
Source: Authors' work based on Eurostat database (2024).

countries, the population over 64 makes up more than 30% of the working age population. The old-age dependency ratio in 2021 was on average about 9 percentage points higher than just two decades ago.

The share of population older than 64 in total population amounted to about 20% in 2021 on average. Considering the presented data in Figure 1 and Figure 2, demographic transition imposes the greatest challenges on Italy, Finland, Greece and Portugal.

Given the explained procedures of panel data analysis and description of all variables, as well as the previous empirical research made by Korwatanasakul, Sirivunnabood and Majoe (2021), the following three basic models will be considered:

(1) Model 1 with old-age dependency as an independent variable of demographic transition:

$$balance_{it} = \beta_1 + \beta_2 agedep_{it} + \beta_3 revenue_{it} + \beta_4 trade_{it} + \beta_5 growth_{it} + \beta_6 unemploy_{it} + u_{it} \quad (7)$$

(2) Model 2 with the share of people aged 65+ in total population as an independent variable of demographic transition:

$$balance_{it} = \beta_1 + \beta_2 share65_{it} + \beta_3 revenue_{it} + \beta_4 trade_{it} + \beta_5 growth_{it} + \beta_6 unemploy_{it} + u_{it} \quad (8)$$

(3) Model 3 with health expenditures as an independent variable of demographic transition:

$$balance_{it} = \beta_1 + \beta_2 health_{it} + \beta_3 revenue_{it} + \beta_4 trade_{it} + \beta_5 growth_{it} + \beta_6 unemploy_{it} + u_{it} \quad (9)$$

Moreover, the following three models with threshold will also be estimated, with X_{kit} denoting independent macroeconomic control variables:

(4) Model 4 with old-age dependency as a threshold variable and an independent variable of demographic transition:

$$balance_{it} = \begin{cases} \beta_1 + \sum_{k=2}^{K} \beta_k X_{kit} + \alpha_1 agedep_{it} + \mu_i + u_{it},\ if\ agedep_{it} \le \gamma \\ \beta_1 + \sum_{k=2}^{K} \beta_k X_{kit} + \alpha_2 agedep_{it} + \mu_i + u_{it},\ if\ agedep_{it} > \gamma \end{cases} \quad (10)$$

(5) Model 5 with the share of people aged 65+ in total population as a threshold variable and an independent variable of demographic transition:

$$balance_{it} = \begin{cases} \beta_1 + \sum_{k=2}^{K} \beta_k X_{kit} + a_1 share65_{it} + \mu_i + u_{it},\ if\ share65_{it} \leq \gamma \\ \beta_1 + \sum_{k=2}^{K} \beta_k X_{kit} + a_2 share65_{it} + \mu_i + u_{it},\ if\ share65_{it} > \gamma \end{cases} \quad (11)$$

(6) Model 6 with health expenditures as a threshold variable and an independent variable of demographic transition:

$$balance_{it} = \begin{cases} \beta_1 + \sum_{k=2}^{K} \beta_k X_{kit} + a_1 health_{it} + \mu_i + u_{it},\ if\ health_{it} \leq \gamma \\ \beta_1 + \sum_{k=2}^{K} \beta_k X_{kit} + a_2 health_{it} + \mu_i + u_{it},\ if\ health_{it} > \gamma \end{cases} \quad (12)$$

3 RESULTS

The estimation results of the model 1 defined by the equation (7) is given in Table 3. Both the F-test and the Breusch-Pagan LM test suggest existence and statistical significance of individual effects, rejecting the pooled specification with constant regression parameters. The Hausman's specification test favours the specification with the fixed-effects. All applied econometric tests indicate that disturbances are not homoscedastic with the same variance across countries and time, as well as that serial correlation is present, which can produce consistent, but inefficient estimates.

Table 4 provides the estimation results of the model 2 defined by the equation (8). As in the model 1, the F-test

Table 3 Estimated results for the model 1 with the old-age dependency

Model specification	Pooled	Fixed-effects	Random-effects
Independent variable explaining population ageing:			
Old-age dependency	0.0244 (0.0304)	-0.1724*** (0.0472)	-0.0698* (0.0364)
Independent macroeconomic control variables:			
GDP growth rate	0.3739*** (0.0336)	0.3553*** (0.0299)	0.3619*** (0.0299)
Government revenue	0.1564*** (0.0223)	0.4470*** (0.0597)	0.2762*** (0.0409)
Unemployment rate	-0.2136*** (0.0302)	-0.2825*** (0.0357)	-0.2373*** (0.0335)
Trade openness	0.0056** (0.0022)	0.0226*** (0.0073)	0.0095** (0.0040)
Constant	-9.5663*** (1.2605)	-18.2576*** (2.4152)	-12.4628*** (1.8363)
Model significance:			
	F(5,561)=55.47 p-value=0.0000	F(5,535)=55.87 p-value=0.0000	Wald $x^2(5)$=266.46 p-value=0.0000
Coefficient of determination:			
	R^2=0.3308 adjusted R^2=0.3249	R^2_{within}=0.3430 $R^2_{between}$=0.2986 $R^2_{overall}$=0.2495	R^2_{within}=0.3404 $R^2_{between}$=0.3356 $R^2_{overall}$=0.3049
Testing for individual effect:			
		F(26,535)=8.70 p-value=0.0000	LM=267.49 p-value=0.0000

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Model specification	Pooled	Fixed-effects	Random-effects
Testing for heteroscedasticity:			
	$x^2(20)=34.35$ p-value=0.0239	$x^2(27)=240.22$ p-value=0.0000	LM=2.69×10^4 p-value=0.0000
Testing for serial correlation:			
	F(1,26)=69.18 p-value=0.0000	BFN=0.90114 $d_{PL}=1.8338$ BFN<d_{PL}→H_0 rejected	LM=102.80 p-value=0.0000
Hausman's specification test:			
		$x^2(5)=22.95$; p-value=0.0003 → fixed-effects	

*Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses.*

Source: Authors' calculations.

and the Breusch-Pagan LM test identify the statistical significance of individual effects, while the Hausman's specification test suggests the fixed-effects specification. The applied econometric tests indicate that the assumptions on homoscedasticity and absence of serial correlation are violated.

The estimation results of the model 3 defined by the equation (9) are presented in Table 5. As in the previous two models, econometric tests reject the pooled model with constant regression parameters, given that individual effects are found statistically significant. The Hausman's specification test favours the

Table 4 Estimated results for the model 2 with the share of people 65+ in total population

Model specification	Pooled	Fixed-effects	Random-effects
Independent variable explaining population ageing:			
Share of people aged 65+ in total population	0.0501 (0.0517)	-0.3005*** (0.0880)	-0.1037* (0.0644)
Independent macroeconomic control variables:			
GDP growth rate	0.3746*** (0.0336)	0.3534*** (0.0300)	0.3618*** (0.0300)
Government revenue	0.1561*** (0.0220)	0.4427*** (0.0598)	0.2715*** (0.0408)
Unemployment rate	-0.2136*** (0.0302)	-0.2815*** (0.0358)	-0.2354*** (0.0335)
Trade openness	0.0057*** (0.0022)	0.0235*** (0.0077)	0.0094** (0.0040)
Constant	-9.7931*** (1.3273)	-17.4700*** (2.4312)	-12.2875*** (1.8771)
Model significance:			
	F(5,561)=55.56 p-value=0.0000	F(5,535)=55.36 p-value=0.0000	Wald $x^2(5)=264.88$ p-value=0.0000
Coefficient of determination:			
	$R^2=0.3312$ adjusted $R^2=0.3252$	$R^2_{within}=0.3410$ $R^2_{between}=0.2995$ $R^2_{overall}=0.2472$	$R^2_{within}=0.3282$ $R^2_{between}=0.3391$ $R^2_{overall}=0.3060$
Testing for individual effect:			
		F(26,535)=8.59 p-value=0.0000	LM=266.40 p-value=0.0000

Model specification	Pooled	Fixed-effects	Random-effects
Testing for heteroscedasticity:			
	$x^2(20)=37.51$ p-value=0.0102	$x^2(27)=246.42$ p-value=0.0000	LM=2.68×10^4 p-value=0.0000
Testing for serial correlation:			
	F(1,26)=69.42 p-value=0.0000	BFN=0.89795 d_{PL}=1.8338 BFN<$d_{PL}\rightarrow H_0$ rejected	LM=102.48 p-value=0.0000
Hausman's specification test:			
		$x^2(5)=21.26$; p-value=0.0007 → fixed-effects	

*Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses.*

Source: Authors' calculations.

Table 5 Estimated results for the model 3 with health expenditures

Model specification	Pooled	Fixed-effects	Random-effects
Independent variable explaining population ageing:			
Health expenditures	-0.9974*** (0.1052)	-2.4370*** (0.1490)	-2.0895*** (0.1381)
Independent macroeconomic control variables:			
GDP growth rate	0.3243*** (0.0315)	0.2452*** (0.0257)	0.2659*** (0.0259)
Government revenue	0.2941*** (0.0240)	0.5413*** (0.0481)	0.4928*** (0.0385)
Unemployment rate	-0.2457*** (0.0282)	-0.3145*** (0.0288)	-0.2969*** (0.0285)
Trade openness	0.0045** (0.0020)	0.0223*** (0.0050)	0.0124*** (0.0037)
Constant	-8.1490*** (1.0540)	-11.1789*** (2.0435)	-10.2671*** (1.6743)
Model significance:			
	F(5,561)=82.12 p-value=0.0000	F(5,535)=131.33 p-value=0.0000	Wald $x^2(5)=598.57$ p-value=0.0000
Coefficient of determination:			
	R^2=0.4226 adjusted R^2=0.4175	R^2_{within}=0.5511 $R^2_{between}$=0.2995 $R^2_{overall}$=0.2472	R^2_{within}=0.5464 $R^2_{between}$=0.2968 $R^2_{overall}$=0.3815
Testing for individual effect:			
		F(26,535)=8.59 p-value=0.0000	LM=495.06 p-value=0.0000
Testing for heteroscedasticity:			
	$x^2(20)=47.77$ p-value=0.0005	$x^2(27)=864.65$ p-value=0.0000	LM=2.85×10^4 p-value=0.0000
Testing for serial correlation:			
	F(1,26)=43.35 p-value=0.0000	BFN=1.0758 d_{PL}=1.8338 BFN<$d_{PL}\rightarrow H_0$ rejected	LM=74.80 p-value=0.0000
Hausman's specification test:			
		$x^2(5)=54.03$; p-value=0.0000 → fixed-effects	

*Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses.*

Source: Authors' calculations.

fixed-effects over the random-effects specification. All applied econometric tests indicate the presence of heteroscedasticity and serial correlation.

The stationarity of all the variables is tested by Fisher-type ADF test proposed by Choi (2001). The optimal number of lags is defined by the Akaike information criterion (AIC). Time trend or drift term are included where needed, in order to describe the process by which the series is generated. The results of the unit-root tests given in Table 6 suggest that all the variables are stationary, and that there is no need for transformation of data through differencing.

Given the identified heteroscedasticity and serial correlation and consequently inefficient estimates in all three estimated models, as well as suggestion of the Hausman's specification test for the specification with the fixed individual effects, Table 7 provides the estimation results for the final models with robust

Table 6 Unit root test results

Variable	Number of lags (AIC)	Trend or drift	Statistic	P-value
Fiscal balance	0	none	106.1054	0.0000
Old-age dependency	1	time trend included	88.9161	0.0019
Share of people aged 65+ in total population	1	time trend included	92.3037	0.0009
Health expenditures	0	drift term included	111.7805	0.0000
GDP growth rate	0	none	384.1095	0.0000
Government revenue	0	drift term included	157.8390	0.0000
Unemployment rate	1	none	103.2621	0.0001
Trade openness	0	time trend included	95.4920	0.0004

Source: Authors' calculations.

Table 7 Estimated results for the final fixed-effects models with robust standard errors

	Model 1	Model 2	Model 3
Independent variable explaining population ageing:			
Old-age dependency	-0.1724** (0.0785)		
Share of people aged 65+ in total population		-0.3005** (0.1494)	
Health expenditures			-2.0895*** (0.1381)
Independent macroeconomic control variables:			
GDP growth rate	0.3553*** (0.0269)	0.3534*** (0.0275)	0.2659*** (0.0259)
Government revenue	0.4470*** (0.1051)	0.4427*** (0.1037)	0.4928*** (0.0385)
Unemployment rate	-0.2825*** (0.0860)	-0.2815*** (0.0861)	-0.2969*** (0.0285)
Trade openness	0.0226** (0.0109)	0.0235* (0.0118)	0.0124*** (0.0037)
Constant	-18.2576*** (5.3600)	-17.4700*** (5.3333)	-10.2671*** (1.6743)

*Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Robust standard errors are reported in parentheses.*

Source: Authors' calculations.

standard errors. Coefficients for all the independent variables explaining population ageing are negative and statistically significant, which means that the population ageing negatively affects the fiscal balance.

The estimation results of the models 4, 5 and 6 defined by the equations (10), (11) and (12) are shown in Table 8. Given the results of the threshold effects tests in all three models, we can conclude that the threshold is not significant in any of the considered models. Although there is a negative relation between population ageing and fiscal balance, there cannot be defined any critical threshold after which population ageing affects fiscal balance and fiscal sustainability more intensely.

4 DISCUSSION

The conducted research provided valuable results. As expected, demographic transition characterized by population ageing have created significant negative impact on the fiscal balance of European countries at the beginning of the 21st century, which was demonstrated by all three models we analysed.

In the model 1, the old-age dependency, as the independent variable explaining population ageing, is statistically significant at the 5% level. The value of the coefficient of -0.1724 means that the increase of the old-age dependency by one-percentage point causes the decrease of the fiscal balance by 0.1724 percentage points.

Table 8 Estimated results for the fixed-effects threshold models

		Model 4		Model 5		Model 6
Independent variable explaining population ageing:						
Old-age dependency (threshold value: 19.87)	≤19.87	-0.3074*** (0.0591)				
	>19.87	-0.1929*** (0.0469)				
Share of people aged 65+ in total population (threshold value: 11.18)			≤11.18	0.0849 (0.1476)		
			>11.18	-0.2843*** (0.0874)		
Health expenditures (threshold value: 3.1)					≤3.1	-4.3305*** (0.5244)
					>3.1	-2.5644*** (0.1511)
Independent macroeconomic control variables:						
GDP growth rate		0.3611*** (0.0296)		0.3691*** (0.0298)		0.2368*** (0.0254)
Government revenue		0.4701*** (0.0594)		0.3715*** (0.0632)		0.5362*** (0.0475)
Unemployment rate		-0.2622*** (0.0357)		-0.2515*** (0.0367)		-0.3186*** (0.0284)
Trade openness		0.0125 (0.0077)		0.0302*** (0.0079)		0.0201*** (0.0049)
Threshold effect test:						
	F-stat=15.30 p-value=0.3500		F-stat=10.72 p-value=0.6733		F-stat=15.30 p-value=0.1333	

*Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses.*

Source: Authors' calculations.

The similar conclusion can be drawn from the estimation results for the model 2. The share of population older than 64 in the total population, as the independent variable explaining population ageing, is also significant at the 5% level. The value of the coefficient of -0.13005 means that the increase of the share of population older than 64 in the total population by one-percentage point is associated with the decrease of the fiscal balance by 0.3005 percentage points.

Health expenditures, as an implicit proxy of population ageing, which is the independent variable in the model 3, is statistically significant even at the 1% level. The value of the coefficient for the health expenditures is the highest, as compared with other independent variables explaining demographic transition, and amounts to -2.0895. That means that one-percentage point higher health expenditures imply fiscal balance lower by 2.0895 percentage points.

The fixed-effects threshold models identified the thresholds of demographic transition indicators, but these thresholds are not found to be statistically significant. That means that population ageing negatively affects the fiscal balance at all levels of population ageing indicators. It is not necessary that population ageing indicators reach a certain level to be able to create a negative impact on the fiscal balance. For instance, the increase of the old-age dependency by one-percentage point will negatively affect the fiscal balance regardless of whether the ratio of people older than 64 to the working-age population is at the level of 20%, or at the level of 30%.

When comparing the estimated models, it can be noticed that the model 3, with health expenditures as the independent variable explaining population ageing, describes the relation between population ageing and fiscal balance in the best way, considering the values of the coefficients of determination and the fact that this model explains up to 55% of variations.

The independent macroeconomic control variables, which are used in the models, are all statistically significant, mostly at the 1% level, except trade openness whose significance varies from the level of 1% to the level of 10%, suggesting that the models are well defined and that appropriate variables are included. All coefficients are with the expected sign, concluding that fiscal balance is positively correlated with economic growth, government revenues and trade openness, but negatively correlated with unemployment rate.

One such empirical research based on panel data was conducted on a sample of 178 countries for the time span of 1991 to 2019 (Korwatanasakul, Sirivunnabood and Majoe 2021). The results are consistent since both studies showed that health expenditures are negatively related to the government balance. The authors also analysed the impact of old-age dependency ratio and the share of the old population, and found a significant positive relationship with health expenditure. Besides, there is an empirical confirmation based on a panel of 26 OECD countries in the period 1970–1997, showed that population ageing is the main force driving the growth of government that could undermine the sustainability of public finance and have important (negative) implications for economic growth (Sanz and Velázquez 2007). There are many empirical studies that analyzed the impact of ageing on economic growth, however, Nagarajan, Teixeira and Silva (2016) classified them depending on different channels of impact such as: social expenditures (Thiébaut, Barnay and Ventelou 2013), taxation, and consumption and saving patterns (Imam 2013).

The number of empirical studies focusing on analysis of the population aging in the European Union on its fiscal balance is surprisingly small considering that the topic is widely discussed in public. Focusing analysis on 14 European countries for the period from 1970 to 2014, Cho and Le (2022) tested the effects of population aging on long-term fiscal sustainability. Using novel methodology based on solvency test (Bohn 2005) and the PSTR model (González et al. 2017), and the old-age dependency ratio as a proxy transition variable, they empirically confirmed that the public pension and health spending have a systematic relationship with the old-age dependency ratio. The cointegration relations and error-correction models record that population aging increases the public pension and health spending; however, this effect is more pronounced in the countries that have recently experienced fiscal crises.

It is evident that population ageing is posing a significant burden on fiscal policy, through upward pressure on age-related expenditures. Additionally, the increase of the old-age dependency ratio is adversely affecting the tax bases and the structure of public revenues (Prammer 2019; Dougherty, de Biase and Lorenzoni 2022; Rouzet et al. 2019). Therefore, demographic transition poses significant challenges for the European Union fiscal sustainability, where policy makers are facing with limiting fiscal policy space.

5 CONCLUSION

The European Union countries are facing the trend of population aging resulting in strong pressure on the fiscal balance. Aiming to provide quantitative confirmation of this relation, the authors carried out a panel data analysis on the sample of 27 the European Union member countries for the period 2001–2021. The empirical research was based on three models where the government fiscal balance, measured as percentage of GDP, was used as dependent variable while as an explanatory variables were used: the old-age dependency ratio (model 1), the share of population older than 64 in total population (model 2) and health expenditures (model 3).

All the models confirmed that population ageing in the EU has significant negative effect on the fiscal government budget. In other words, the increase of: 1) the old-age dependency by one-percentage point causes the decrease of the fiscal balance by 0.1724 percentage points; 2) share of population older than 64 in the total population by one-percentage point is associated with the decrease of the fiscal balance by 0.3005 percentage points; and 3) health expenditures by one-percentage point imply lower fiscal balance by 2.0895 percentage points. What is more, this negative impact is evident for all the levels of population ageing indicators, confirming that it is not necessary for any population ageing indicator to reach a certain level to create a negative impact on the fiscal balance. For ensuring robustness of the results, independent macroeconomic control variables (the real GDP growth rate, government revenue, unemployment rate and trade openness) were used, and the test confirmed that all three models are well

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defined and that appropriate variables are included.

Since all the projections are pointing to a growing trend of population ageing in the European Union, and empirical results confirm the negative effects of the demographic transition on the government budget, it is necessary to take certain measures in the domain of public policy. Although it is to be expected that interventions will be undertaken in terms of strengthening the fiscal policy, the following limitations should be kept in mind. First, the fiscal space is significantly limiting because of an increase in aging-related expenditures (where pension spendings have the largest share) and decrease of the tax base related to the smaller number of working population who are taxpayers. This problem becomes even more pronounced in countries that already have a high level of public debt (Italy, Portugal, Belgium, Spain). Second, the room for manoeuvring and the effectiveness of fiscal policy is further narrowed in the recession period because the older population is more difficult to increase aggregate consumption (due to risk aversion, personal consumption and investments will decrease). As a result, fiscal policy activities that have a higher fiscal multiplier are reduced, which negatively affects economic growth in the long term. Third, the effectiveness of automatic stabilizers, which have been widely applied since the 2000s in order to prevent macroeconomic fluctuations, will be decreasing in the future. Hence, it can be concluded that the debt dynamic and available fiscal space largely depend on the interest rate growth differential. While members of the European Union previously benefited from a favourable, i.e. negative, interest rate growth differential, impact of aging on public debt will largely depend on further movements of the interest rate and growth rate (which is expected to stagnate).

Although the fiscal space for interventions is narrowing, there are always available measures related to enhancing the efficiency of health care provision, incentivising private savings and well-targeted pension reforms that will stimulate older workers to remain active for longer. Besides, labour market reforms should be considered in order to increase the participation of older workers in the labour market, as well as better inclusion of women and youth. Although the inflow of migration alone cannot solve the problem of the aging population, all possibilities for their faster integration into the labour market should be considered. There should be continuity in work on improving public finances and give priority to the so-called "growth-enhancing public spending".

In addition, it should be kept in mind that the dynamics of population aging differs from one country to another, and consequently all projections across Member States, for both the time profile and the projected change in spending, are different, and therefore the effects of population aging also differ in their fiscal sustainability. What is more, demographic transition can lead to growing differences between countries and increasing economic instability in the European Union as an economic and political integration region. Hence, it is very important to find an answer to the questions such as how to tailor the assessment to country-specific circumstances. Certainly, searching for an answer to that question requires a deeper analysis and may be the subject of research in a subsequent paper.

The limitations of the paper mainly relate to the scope of variables used and the time covered. The coefficient of determination ranges from about 30 percent to the maximum of 55 percent, indicating that there is a solid amount of variation in the fiscal balance that is not sufficiently explained by the model. For example, some important data on private health expenditure were not included in the analysis due to unavailability of data. The period of the analysis was limited to 20 years, because for a longer period, it has not been possible to collect comparable and balanced data for all variables and countries, which would certainly contribute to higher quality results of the analysis.

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Data Availability Statement

Data are available from the authors upon request.

Coauthor contributions

Sanja Filipović: conceptualisation, resources, investigation and writing. **Marko Miljković**: methodology, formal analysis, software, writing.

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Uticaj starenja stanovništva na fiskalni bilans Evropske unije

PROŠIRENI SAŽETAK

Zemlje Evropske unije (EU) se suočavaju sa problemom starenja stanovništva i posle Japana imaju najveće učešće starih u ukupnoj populaciji. Procenjuje se da će se broj stanovnika, uprkos prilivu migranata, nakon 2035. godine smanjivati, dok će koeficijent starosne zavisnosti (odnos broja starijih od 65 godina i ukupnog broja radno sposobnih) rasti. Cilj ovog rada je da utvrdi efekte starenja stanovništva na fiskalni bilans EU. Uprkos važnosti ovog pitanja, broj empirijskih radova koji istražuju pomenutu relaciju na primeru zemalja EU je zanemarljiv.
Empirijsko istraživanje je sprovedeno primenom ekonometrijskih metoda na bazi panela podataka za 27 zemalja EU za period 2001–2021. godine. Primenjena su tri modela gde je kao zavisna varijabla korišćen fiskalni bilans države, meren kao procenat bruto domaćeg proizvoda (BDP), a kao nezavisne varijable korišćeni su: koeficijent starosne zavisnosti (model 1), udeo stanovništva starijeg od 64 godine u ukupnoj populaciji (model 2) i izdaci za zdravstvo (model 3). Svi modeli su potvrdili da starenje stanovništva značajno negativno utiče na fiskalni bilans, odnosno da porast: 1) koeficijenta starosne zavisnosti za jedan procentni poen (p. p.) smanjuje fiskalni bilans za 0,1724 p. p.; 2) učešća stanovništva starijeg od 64 godine za jedan p. p. smanjuje fiskalni bilans za 0,3005 p. p. i 3) izdataka za zdravstvo za jedan p. p. impliciraju niži fiskalni bilans za 2,0895 p. p. Štaviše, ovaj negativan uticaj je evidentan na svim nivoima indikatora starenja stanovništva, potvrđujući da nije neophodno da bilo koji indikator starenja stanovništva dostigne određeni nivo da bi stvorio negativan uticaj na fiskalni bilans. Provera na bazi nezavisnih makroekonomskih kontrolnih varijabli je potvrdila da su sva tri modela dobro definisana i da su uključene odgovarajuće varijable.
Kako bi se obezbedila održivost javnih finansija, kreatori ekonomske politike treba da preduzmu određene mere. Međutim, u domenu fiskalne politike prostor se sužava iz nekoliko razloga: a) rastu rashodi za starenje stanovništva (gde penzije imaju najveće učešće), a poreska osnovica se smanjuje zbog manjeg broja radno aktivnog stanovništva; b) kako starija populacija teže povećava agregatnu potrošnju, smanjuju se i aktivnosti fiskalne politike koje imaju veći fiskalni multiplikator, što dugoročno negativno utiče na privredni rast, c) smanjuje se efikasnost tzv. automatskih stabilizatora, tako da će uticaj starenja stanovništva na javni dug zavisiti od odnosa nivoa kamatne stope i stope rasta BDP. Pa ipak, na raspolaganju su mere koje se odnose na povećanje efikasnosti pružanja zdravstvene zaštite, podsticanje privatne štednje i dobro ciljane penzione reforme. Osim toga, treba razmotriti reforme tržišta rada kako bi se povećalo učešće starijih radnika, žena, mladih i migranata.

KLJUČNE REČI

fiskalni bilans, starenje stanovništva, javni rashodi, troškovi zdravstva, Evropska unija

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