The impact of population aging on public finance in the European Union

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Abstract

Population aging is a process that shapes the economic environment in most of the developed economies. Thus, understanding the dynamics between public finance and the demographic variables enables policy-makers to adapt and to ameliorate their medium-term budgetary frameworks. The aim of this paper is to examine the fiscal implications of the demographic shift using panel data on 25 EU countries in the period from 1995 until 2014. In order to qualify the findings of previous literature, this paper considers the demographic variables as endogenous and applies the system GMM estimator to obtain the elasticity of several public finance categories with respect to population aging. The results indicate significant and positive impacts of the elderly share on expenditure for pensions and social protection. The higher positive impact on overall public expenditure compared with total government revenue confirms the negative effect of population aging on budget balance. An increase in the young population has a significant impact only on health expenditure.

Keywords: population aging, demographic transition, public finance, system GMM

1 INTRODUCTION

Although the Great Financial Crisis[1] has had a significant impact on the global economy, it is the demographic transition that is still one of the biggest challenges facing the European Union (EU) and other developed countries. The baby boom, which in Europe occurred between 1950 and 1970, and the subsequent decline in the fertility rates with an increase in longevity, implicitly indicated significant changes in the total population with respect to its age structure. Consequently, public budgets and other macroeconomic variables are already affected with this structural shift of population. The economic crisis emphasized the importance of fiscal policy in preventing and restraining short-term fluctuations, but the impact of the demographic shift on public finance is less discussed. In the coming decades, the demographic transition will re-shape the economic environment in both developed and developing countries.

Concerning public budgets, demographic changes will modify the structure and the size of public expenditures and revenues. In order to sustain the current welfare-state models in Europe, economic agents must be prepared for long-term reforms in their legislative and taxation systems. With the ever-growing elderly part of population, the current and future labor force could expect increases in their income and indirect taxes, such as value added tax (VAT) and duties. Also, in order to finance pension benefits, the taxation of capital (i.e., tax on capital income, tax on dividends and tax on real estate) will gain in importance. Overall, the extent to which labor and capital are taxed may change in the future with demographic transition.

The most obvious change in public expenditures is predicted in age-related expenditures, such as pensions, medical care and long-term care. Indirectly, the increase

[1] The economic crisis that started in 2008 following the Lehman Brothers bankruptcy filing.

of elderly population influences other budgetary categories such as expenditures for education. It is expected that the increase in the elderly cohort, by decreasing the pupil-to-teacher ratio, will bring into consideration the efficiency of allocating the current level of expenditures for education. Ultimately, public investments can be affected if resource allocation dilemma arises between investments and social protection expenditures. On the other hand, the size and the structure of budget revenues are unlikely to remain equal over the course of time as the population becomes older. The revenues accumulated through the value added tax are affected by changes in aggregate consumer behavior and the revenues from personal income tax are influenced as a result of the shifts in the labor market.

The aim of this paper is to estimate the influence of demographic aging on public finance in 25 EU member states[2] with time observations from 1995 to 2014. We use 4-year intervals to obtain medium-term dynamics corrected for short-run economic fluctuations. The static empirical model used in Callen, Batini and Spatafora (2004), and Yoon, Kim and Lee (2014) is expanded by the introduction of lagged dependent variables and more control variables. Previous studies which included demographic variables considered demographic changes as exogenous, denying the plausible reverse causality in the medium-run between fiscal and demographic variables. Thus, we introduce demographic variables as endogenous in the model. Employing a robust one-step system-GMM estimator, we find evidence of the positive effect of the elderly share on old-age pension expenditure, social protection expenditure, overall government expenditure and revenue. The overall impact on the budget balance is negative as influence is higher in case of government expenditure. On the other hand, the rise in the young population has a significant, and positive, impact only on health expenditure.

The main research question is whether population aging has an impact on certain categories of the public budget, as well as the overall budget balance, in light of the endogenization of demographic variables. The research hypothesis predicts a positive impact of population aging on all fiscal variables, thus following the results of the previous literature, but with more accurate estimates given by the introduction of an enhanced methodology.

The remainder of the paper is organized as follows. Section 2 presents demographic trends and projections in selected EU countries, while fiscal expenditure projections are the subject of section 3. Section 4 reports an overview of the theoretical framework that establishes general equilibrium with the demographic component included. Section 5 provides empirical findings from previous literature investigating the impact of population aging on public finance and the economy. Section 6 contains empirical analysis with the methodology elaborated in subsection 6.1, whereas subsection 6.2 describes the data. Subsection 6.3 presents empirical model and results. Section 7 concludes.

[2] Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Latvia, Lithuania, Sweden, Finland, United Kingdom, Romania, Croatia, Slovenia, Slovakia, Poland, Hungary, Cyprus, Italy, Austria, France, Spain, Portugal, Netherlands.

2 DEMOGRAPHIC PROJECTIONS AND TRENDS

As in other developed countries, the population of the EU has experienced changes in the age structure, with an increasing proportion of elderly population accompanied by a decrease in youth population. However, contemporaneous population aging is the outcome of changes in fertility, mortality and migration that occurred in the past. Therefore, this section will present projections of fundamental demographic determinants that cause the population aging. In addition to that, the projections of indicators considered to be result of past demographic shifts are also displayed.

In 2014, Eurostat published its demographic projections EUROPOP13 for the period 2013-2060, based on the dynamics of key demographic variables: fertility rate, life expectancy and migration flows. The methodology followed "the convergence approach", which assumes that the demographic determinants across all countries of the EU converge in the long run. Total population of the EU is expected to increase from 507 million in 2013 to 523 million in 2060, reaching its peak in 2050 with 526 million inhabitants. However, population growth is different among EU countries as approximately half of them will have lower populations in 2060 than in 2013, whereas other half will experience population growth. The total fertility rate (TFR) indicates the average number of children born to a woman if she lives to the end of her fertile years and bears children according to the age-specific fertility rates in a given year. It is projected to increase in almost all member states, with the exception of France, Sweden and Ireland where it is expected to decrease, whereas in the UK it will remain unchanged. On the aggregate level, the average TFR will rise from 1.59 in 2013 to 1.76 in 2060, which is well below the natural replacement rate of 2.1.

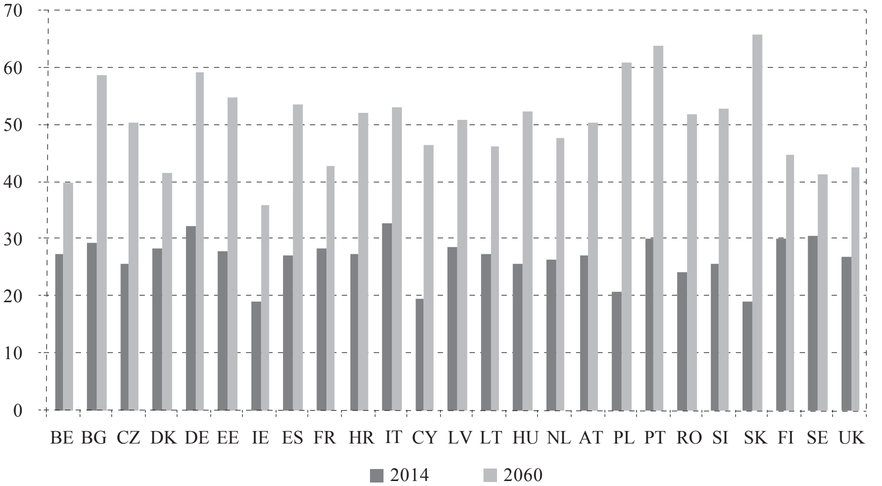
Life expectancy at birth is projected to increase for both males and females over the period 2013-2060 in all member states, with the largest rise in the countries that had the lowest expectancy in 2013 (the Baltic countries, Romania, Bulgaria and Hungary). In the EU as a whole, life expectancy for males will increase from 77.6 years in 2013 to 84 years in 2060, while women are expected to live 89.1 years in 2060, whereas in 2013 life expectancy at birth for females was 83.1 years. However, life expectancy trends are subject of debate among demographers as future medical breakthroughs, changes in social behavior (prevention of obesity and decrease in smoking rates) and the long-term impact of public health programs may influence the realization of current projections. Thus, it is argued that the budgetary impact of population aging may be underestimated.

As in previous years, it is expected that the EU will maintain positive net migration flows until 2060. The number of immigrants will increase from 874 000 in 2013 to 1.07 million in 2060 reaching its peak in 2040. Among the EU countries, it is expected that Spain, Italy, UK and Germany will account for the bulk of overall immigration flows in the EU. However, it is important to note that migration flows are highly prone to changes in economic and political situations and therefore are difficult to predict. Optimistic economic projections made in 2013, as well as the omission of the massive political immigration from the Middle East and Africa caused by conflicts, may result in underestimated figures for both immigration and emigration. In 2013, when Eurostat compiled population projections for the next 50 years, it is highly unlikely that the massive refugee crisis from Syria and other Middle Eastern countries to Europe in 2015 was accounted for. Moreover, migration among EU countries due to asymmetric economic shocks should also be taken in consideration. The economic crisis that started in 2009 resulted in emigration flows from Central and Eastern European as well as Mediterranean countries towards Northern countries of the EU.

The total fertility rate, life expectancy at birth and net migration flows are key demographic indicators and are considered to be the main drivers of population aging. However, the outcome of population aging is captured by dependency ratios, which will be the main subject of this research. While changes in the fertility rate and life expectancy exert influence on economies with lags of several decades, variations in dependency ratios have a more contemporaneous effect on an economy.

Figure 1

Old-age dependency ratio projections (in %)



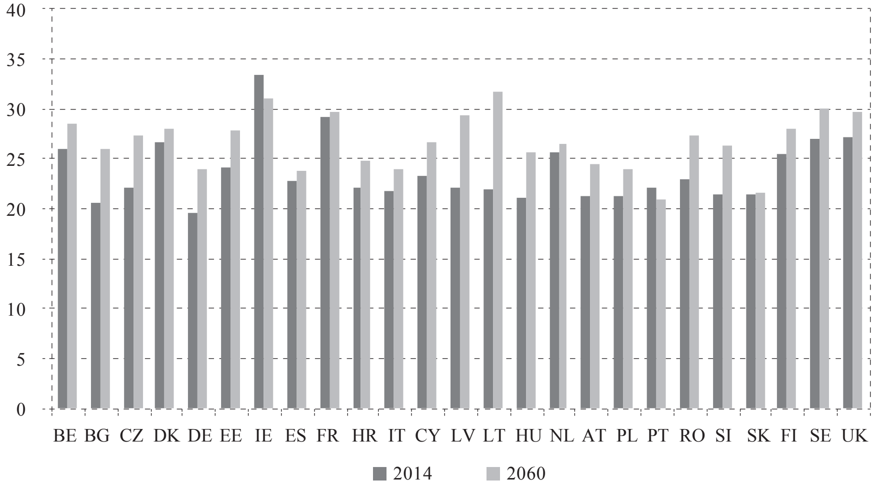
Source: Eurostat (EUROPOP13).

The old-age dependency ratio (henceforth OADR) is the ratio of the population aged 65 or above relative to the population aged 15-64. Figure 1 presents projections of the OADRs for 2014 and 2060. According to projections for selected countries, an average increase of 92.89% over the period 2014-2060 is expected. In 2014, the average OADR was 26.7 and it is expected to increase to 50.4 in 2016, meaning that for every person aged 65 or over there will be approximately two working-age persons. Slovakia will experience the highest growth of 268.84%, as its OADR in 2060 is projected to be 65.9. This implies that for every person older than 65 there will be only 1.51 working-age persons in Slovakia. On the other hand, Sweden will face the lowest increase among observed countries, projected to be 35.29%.

Young-age dependency ratio (henceforth YADR) is the ratio of the population aged 0-14 relative to the population aged 15-64. As can be seen in figure 2, all countries will experience an average increase of 13.32% in the YADR, with the exception of Portugal and Ireland where decreases of 5.5% and 7.13% respectively will occur. On the aggregate level, the average YADR is expected to rise from 23.72 in 2014 to 26.68 in 2060, which means that YADR will roughly remain constant as there will be approximately four working age persons to every member of the 0-14 cohort over the whole period.

Figure 2

Youth-age dependency ratio projections (in %)

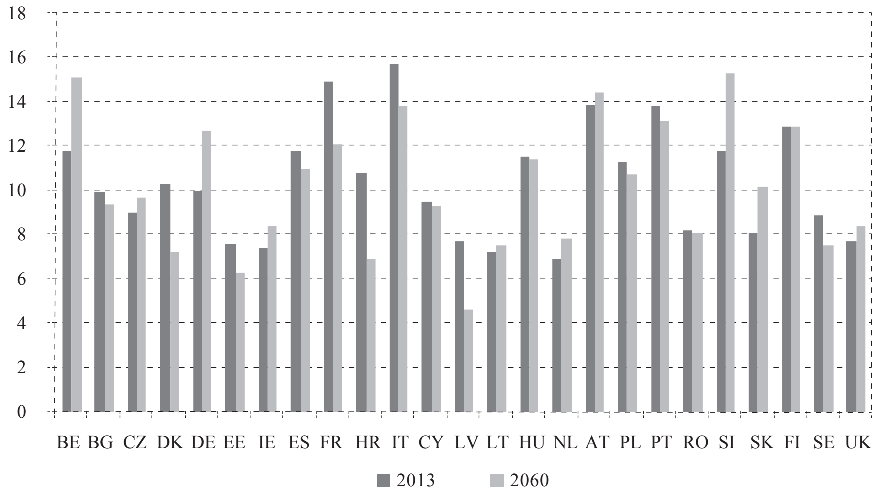


Source: Eurostat (EUROPOP13).

3 FISCAL EXPENDITURE PROJECTIONS

The European Commission (2015) made budgetary projections for health and pension system expenditures based on the EUROPOP2013 demographic projections, which were presented in the previous section. The projections for level of gross public pension expenditure as a percentage of GDP can be seen in figure 3. On the aggregate level, public pension expenditures will increase from an average of 10.34% in 2013 to 10.47% in 2060. However, there are large differences among countries as half of them will face an increase in public pension expenditure, while in the others it will decrease or remain stable. The highest increase will occur in Ireland and Lithuania (35.14% and 30.56% respectively), the largest fall in public pension expenditure over the 2013-2060 period is expected in Latvia and Croatia, with decreases of 29.87% and 27.78% respectively. However, it should be noted that in these two countries, the evolution of public pension expenditure is a result of changes in public pension system parameters rather than demographic factors.

FIGURE 3
Public pension expenditure projections (% of GDP)



Source: European Commission (2015).

The counterintuitive evolution of public pension expenditure in the period 2013-2060 can be explained by the decomposition in four drivers: dependency ratio effect, coverage ratio effect, benefit ratio effect and labor market effects. According to the European Commission (2015), increase in the OADR is the main driver of increase in the level of public pension expenditure and its contribution is larger than the total change over 2013-2060. It is estimated that on the aggregate EU level, the dependency ratio effect increases public pension expenditure by 7.2 percentage points of GDP.

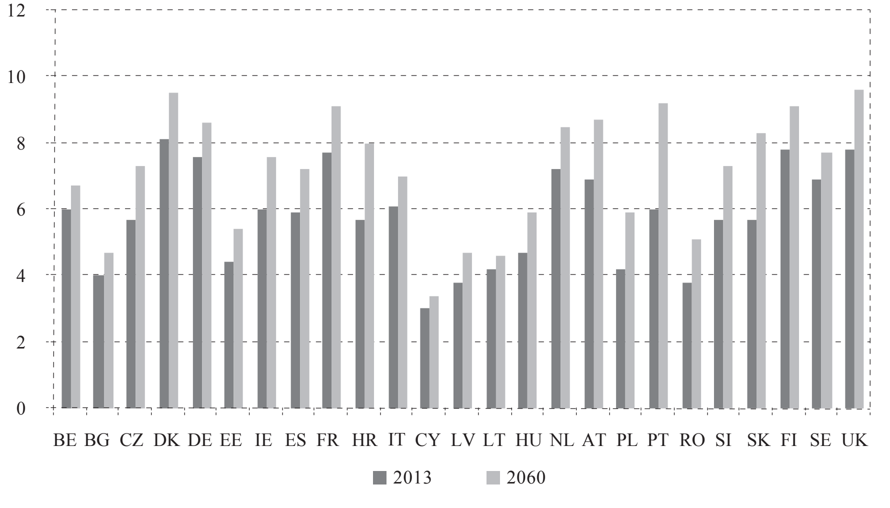
However, the negative effect induced by increase in the OADR is almost completely offset by the other three drivers. Coverage ratio is defined as the number of all pension benefit recipients of a population older than 65 years. In all countries, with the exception of Sweden, a decrease in the coverage ratio is predicted. Reduction in the coverage ratio is mainly attributed to several reforms in public pension schemes across the member states. These reforms took the form of increasing the statutory retirement age, stricter eligibility criteria for early retirement pensions and providing incentives to stay longer in the labor market. The labor market effect exerts a negative impact on public pension expenditure because of the measures aimed at increasing labor supply, which improves the sustainability of public pension systems. Finally, the benefit ratio effect is calculated as the ratio of average pension and average wage, and it reflects the generosity of pension systems. Measures like price indexation decrease the benefit ratio effect, and in all countries of the EU, the benefit ratio effect will decrease the level of pension expenditure in the period 2013-2060.

After public pension expenditure, population aging is expected to be manifested in health care expenditure (henceforth HCE) as the elderly population is a relatively larger user of health services than the younger population. However, the level of HCE depends on the supply and demand for medical goods and services. The demand side is represented by the demographic structure and health status of the population and the level of individual and aggregate income, while the supply side is determined by technological progress, accessibility of medical services and institutional framework. The European Commission's (2015) projections for HCE were created in several scenarios simulating different changes in the above mentioned supply and demand determinants.

The demographic scenario captures exclusively the population aging effect on HCE. However, it assumes that per capita spending grows in line with GDP per capita which may underestimate the level of expenditures. Thus, figure 4 presents health care expenditure projections in the "income elasticity scenario" which assumes income elasticity higher than 1 implying that health care is a luxury good. In figure 4 the evolution of HCE over the period 2013-2060 in the income elasticity scenario can be seen. According to the projections, health expenditure is expected to increase in all countries from 2013 to 2060, with an average rise of 24.07%. Portugal and Slovakia are projected to face the highest growth of HCE, amounting to 53.33% and 45.61% respectively. On the other hand, the smallest increase is projected in Lithuania where health care expenditures will rise 9.52%.

Figure 4

Health care expenditure projections (income elasticity scenario), % of GDP



Source: European Commission (2015).

4 THEORETICAL FRAMEWORK

The demographic component was first introduced in the fiscal policy model created by Auerbach and Kotlikoff (1987) who built an overlapping generations (henceforth OLG) model in a dynamic general equilibrium framework for a closed economy. In the modification of the previous model, Auerbach and Kotlikoff (1989) introduced international trade, bequest behavior, technological change and government consumption expenditures depending on the age structure of the population. More recently, many authors simulated general equilibrium models with country-specific parameters based on a small open economy OLG model (Börsch-Supan et al., 2006; Jimeno et al., 2008; Kudrna et al., 2015). In the following paragraphs, a short description of the OLG model for a small open economy is provided.

The economy is characterized by four agents: households, firms, government and international sector. The household sector consists of 75 overlapping generations with children aged 1-20 and adults aged 21-75. Every year, a new-born generation replaces the last dying generation. At the age of 21, a child becomes an adult independent of parental support, and becomes a parent with an exogenously given number of children. A parent supports children from the age of 21 until 41. The individuals in an age cohort have identical preferences and have perfect foresight. Life-time utility function of an adult is the sum of his utility based on the current and the future values of consumption and leisure, his children's utility and legacy per child (bequest motives) distributed equally among children in the last year of life. Maximization of the life-time utility of an adult with the life-time budget constraint results in optimal values of consumption, leisure and bequest motives. Firms are represented with single production sector operating in a perfectly competitive economy. The production is represented by a Cobb-Douglas production function with constant returns-to-scale and homogenous labor input and capital. Firms optimize their profit function by minimizing the costs of labor and capital whose prices are established on primary input markets.

The government consists of the fiscal authority and the social security system. Fiscal authority is represented with four categories of public expenditures, one of which is not age-related (such as national defense) while the other three categories are aimed at three age cohorts, 1-24, 25-64, and 65 and over. The social security system operates with a balanced budget and involves social benefits funded by payroll taxes. Government's inter-temporal budget constraint requires that the present value of government expenditure and public debt equals the present value of tax receipts.

The open economy assumption considers wages and interest rates to be given in the international environment and therefore exogenous. Also, it allows for the difference between an economy's assets and domestic capital stock. If domestic capital stock is lower than an economy's assets, the country is net borrower, which is manifested negatively in its current account. However, Miles (1999) considers an endogenous interest rate in a small open economy as population aging affects nearly all the developed countries.

General equilibrium is established when all economic agents behave consistently with the current and the future market-clearing prices. Economic agents have perfect foresight, which introduces a correlation between future economic developments and the present conditions of economy. Households optimize labor supply and consumption, while firms make investment decisions based on future behavior of wages and interest rates. Government consumption must satisfy the intertemporal budget constraint.

A different theoretical framework is proposed by Blanchard (1985) who introduces a general equilibrium framework with market imperfections. Its advantage is the inclusion of a less crude demographic structure and consideration of the notion of uncertainty in the expected duration of life, which enables incorporating markets for life annuities. However, its drawback is the assumption of an equal propensity to consume out of cross-generational wealth while omitting the differences in asset ownership across generations induced by differences in inheritance. Empirical studies such as those of Heijdra and Romp (2009) and De la Croix et al. (2013) follow the tradition of Blanchard's model.

5 LITERATURE OVERVIEW

5.1 EMPIRICAL EVIDENCE ON MACROECONOMIC VARIABLES

Apart from the impact on public finance, which will be in the focus of this paper, an increase in the elderly share influences other macroeconomic variables such as GDP per capita, through labor market and savings, and inflation. The correlation between economic growth and population aging is a subject of debate among economists, as empirical evidence depends on the examined growth model (exogenous vs. endogenous) and other behavioral and accounting effects. Prettner (1995) using the endogenous growth model of Romer (1990) finds a beneficial influence of population aging on per capita output growth, whereas in Jones' (1995) framework of semi-endogenous growth model it depends on changes in fertility and mortality.

Hviding and Mérette (1998) detect a negative impact using an exogenous growth model while Fougère and Mérette (1999) extend previous research using an endogenous growth model and find a positive influence on economic growth through increased investment in human capital. Bloom et al. (2011) claim that population aging "poses challenges that are formidable, but not insurmountable". They distinguish between accounting effects, where age-specific behavior with respect to savings and labor supply is immovable, and behavioral effects where the pattern of consumption, saving and labor participation changes with the demographic transition. In the former case, a small decline in income per capita growth is foreseen in the OECD countries as a fall in labor supply per capita occurs. However, taking into account behavioral effects that increase working life and savings, adverse effects of population aging can be tempered. Unclear effects of population aging due to behavioral changes are confirmed in research by Börsch-Supan et al. (2014). Furthermore, Bussolo et al. (2015) provide extensive research into the main drivers and consequences of the aging process in Europe and Central Asia. The key conclusions are differentiation among various drivers of aging in the world with a decline in the fertility rate being the main factor behind aging in Europe and Central Asia. Also, they point out the opportunities that aging might have for the economy through behavioral changes of firms and workers with the final outcome being more optimistic compared to the more "apocalyptic" economic consequences of population aging.

Furthermore, inflationary implications of an increase in the elderly share are not unanimously determined as Bullard et al. (2012) and Shirakawa (2012) contend that older cohorts prefer higher rate of savings and low steady-state rate of inflation, while Juselius and Takáts (2015) provide empirical evidence of inflationary pressures connected with a larger share of young and old dependent cohorts. Katagiri et al. (2014) separate the final effect of aging on inflation with respect to forces causing the demographic process. Population aging is deflationary if it is induced by an increase in longevity while it is inflationary if it stems from a drop in the birth rate.

5.2 EMPIRICAL EVIDENCE ON FISCAL IMPACT

To the best of the author's knowledge, one of the first studies addressing the issue is that of Auerbach and Kotlikoff (1985). Testing the implications of demographic transition in the case of United States, they predict dramatic hikes in the payroll tax, substantial improvement in the social security system and radical cuts in benefits. Auerbach et al. (1989) arrive at similar conclusions improving their previous model with an open-economy assumption in an investigation of the impact of aging in Japan, Germany, Sweden and the United States. Yashiro et al. (1997) create a general equilibrium model for Japan in order to capture the fiscal implications of demographic aging and propose reforms to mitigate adverse effects. Their results correspond to the theoretical framework as the adverse effect on the public budgets is confirmed. Díaz-Giménez and Díaz-Saavedra (2009) compute a calibrated OLG model for Spanish economy and arrived at the conclusion that the public pension system is unsustainable under the predicted demographic developments.

Kudrna et al. (2015) develop a small open economy, the OLG model with nonstationary demographic paths for Australia. As a result of increases in age-related expenditure, they predict significant adjustments in other government expenditures and taxes to offset the effect of a demographic shift. More interestingly, increases in fertility and immigration are excluded as possible solutions to the fiscal challenges. King and Jackson (2000) in their empirical research for Canada conclude that population aging alone will not pose major challenges to the public finance. However, they stress the importance of government debt reduction in the short-term, which would enable more room-to-maneuver in the long run.

As for the literature investigating the impact of an aging population on specific categories of public expenditure, the most represented is the area of health economics. Chawla et al. (1998) conduct a multivariate analysis of health expenditures on annual data for Poland spanning the years from 1960 until 1995. They find a positive and weak correlation between a population aged over 65 and health expenditures. Di Matteo and Di Matteo (1998) using a pooled OLS regression for Canada's provinces suggest that an increase in the proportion of the population over 65 will add on average about 1.3% per year to the real per capita provincial government health expenditures. Di Matteo (2005) expands the previous research by introducing state-level data for the US along with province-level data for Canada. The results confirm the positive impact of an increase in the elderly share in models without time variables. However, when the model includes time variables, which are used as proxy for technological change, a relatively smaller proportion of health expenditures is explained by the age distribution of the population and income per capita.

Prieto and Lago-Peñas (2010) argue that the model specification and econometric technique affect results for determinants of health expenditures. Analyzing data for 17 Spanish regions for the period 1992-2005 and using the OLS regression and fixed effects, they find evidence of positive impact of elderly population on health expenditures. However, they raise concerns over multicollinearity bias when many age cohorts are included. Martín et al. (2011) review the literature on health care expenditure for the period 1998 to 2007. In their sample of 20 studies included, six of them emphasize population aging as the key determinant. However, they concluded that there is no solid empirical evidence in favor of attributing population aging as one of the principal determinants, whereas technological advances, closeness to death and territorial decentralization arise as important factors in explaining development of health care expenditures. Xu et al. (2011) investigate health care expenditure determinants in 143 countries divided into income groups over the period 1995 to 2008. They estimate a static model using fixed effects and a dynamic model with system-GMM estimator. In the static model, an increase in the elderly share has a positive impact only in lower-middle income countries. On the other hand, in the dynamic model for any income group, elasticity of population aging is insignificant.

Lusky and Weinblatt (1998) run the OLS regression for 127 countries to estimate the fiscal pressures of demographic shifts. They find that the share of elderly population has a positive and significant effect on the share of government health expenditure in GDP, while increases in both young and elderly populations increase social welfare expenditure. Labrador and Angona (2003) use a one-step first-difference GMM estimator to test median voter theory on a sample of 26 OECD countries over the period 1970-1997. They confirm the negative elasticity of the elderly share on public services and housing. On the other hand, they conclude there is a positive impact of an increase in the elderly share on social security and health expenditures. The increase in the younger population positively affects health and education expenditures, while reducing military and other expenditures.

Callen, Batini and Spatafora (2004) investigate the impact of demographic aging on several economic performance indicators, among other things, budget balance-to-GDP ratio. They detect a negative correlation between the increase in the share of the elderly population and the budget balance for a sample of 115 countries over the 1960-2000 period using panel fixed-effects regression. Yoon, Kim and Lee (2014) in their analysis for OECD countries and Japan confirm the overall negative impact of demographic aging on budgetary balance since the positive impact of the increase in the elderly share on public expenditures is higher than the positive impact on public revenues. Hondroyiannis and Papapetrou (2008) examine the data for Greece over the period 1960 to 1995 using a vector error correction model and present empirical findings in favor of the long-run positive effect of the aging process on public debt and expenditure, while decreasing the tax revenues. However, Chen (2004) provides evidence in favor of a weak and negative influence of population aging on the budget balance only in the developing countries, while in the developed countries an increase in the elderly population tends to decrease the budget deficit.

6 EMPIRICAL ANALYSIS

6.1 DATA

The sample covers 25 EU member states, Greece, Luxembourg and Malta excluded. Greece is omitted due to the scarce statistical data on public finance and the economic depression. Luxembourg and Malta are not included because of their small populations. Time observations go from 1995 to 2014 with averaged 4-year intervals so the final dataset has 5 time observations. In this manner, the empirical results represent the medium-term dynamics corrected for short-term fluctuations. The overall dataset is unbalanced, with the number of observations ranging from 107 to 125, considering the differences in the length of time-series data among the variables.

Dependent variables are the total public expenditure and revenues, and the size of age-related expenditure categories (pension expenditure, health care expenditure and social protection expenditure[3]). All fiscal variables are expressed as share-of-GDP ratio to account for heterogeneity of levels among the countries. On the right hand side, key standardized coefficients are estimated for the demographic variables, old-age dependency ratio and young age dependency ratio. OADR and YADR are measured as percentages since they are calculated as ratio of two shares. An increase in either of the two variables indicates a rise in the youth or elderly population with respect to the working share.

Other control variables are real labor productivity, unemployment rate, government efficiency, trade openness and crude net migration rate. Trade openness is expressed as the percentage of trade imports and exports in GDP and represents

[3] Social protection expenditure can be divided by function into different categories: old age, sickness and disability, survivors, family and children, unemployment, housing and R&D social protection.

the influence of international trade on a country's economic environment. Rodrik (1998) points out a positive correlation between trade openness and the size of governments, as government spending reduces an economy's external risk.

Economic determinants of fiscal variables are included through real labor productivity per person and the unemployment rate. The former is measured as a base index with base year 2010, and in per person terms. The latter is the share of unemployed over labor force in percentages. Real labor productivity has been included due to its connectivity with GDP per capita and to test whether the productivity growth really is the most significant determinant of health care expenditures. The unemployment rate controls for the economic cycle effects on the public finance.

Crude net migration rate is the difference between the number of immigrants and emigrants with respect to the average size of the population in a given year. It is measured in percentage points with a positive value representing net inflow in the country. The reason for its inclusion in the research is to demystify the effect of migration on certain public finance categories and to test the conclusions of previous literature which suggest migration might be a solution for population aging.

Institutional differences among a wide range of EU countries are controlled with the estimate of government effectiveness. Government effectiveness is one of the six dimensions in World Governance Indicator (WGI) available in the Data Bank (World Bank). It captures perceptions of quality of civil and public services and the level of government's autonomy from political pressures. Also, the quality of policy-making and credibility for implementation of policies are included. Estimates present a country's score on the overall governance indicator in units of a standard normal distribution spanning from -2.5 to 2.5.

TABLE 1
Summary statistics

Variable	Mean	St. dev.	Min.	Max.	Observations
Public expenditure	45.13	6.43	32.60	60.35	121
Health expenditure	5.75	1.60	1.73	8.63	121
Pension expenditure	7.89	2.51	2.60	13.75	107
Soc. protection expenditure	16.12	4.24	7.60	24.75	121
Public revenues	42.17	6.63	29.90	57.65	124
OADR	23.24	3.66	15.95	32.28	124
YDR	25.38	3.73	19.08	37.93	124
Real labor productivity	91.42	13.30	47.85	109.25	123
Unemployment	9.16	3.77	3.68	24.20	120
Government effectiveness	1.15	0.66	-0.62	2.25	125
Trade openness	99.24	37.47	45.19	209.08	125
Net migration	1.14	4.89	-11.78	20.55	125

Source: Author's calculations.

All variables, except for trade openness and government effectiveness, are downloaded from the Eurostat database. Trade openness and government effectiveness are available in the World Bank Data Bank. In further analysis, most of the variables will remain in percentages to facilitate the interpretation of standardized coefficients, since it does not make sense to take logarithms of percentages. Real labor productivity and estimates of government effectiveness are later converted to natural logarithms. The summary of descriptive statistics for the variables is available in table 1.

6.2 METHODOLOGY

Since it is reasonable to assume that public expenditure and revenues are persistent after controlling for business cycles, as they depend highly on their values in the previous period, the dynamic panel model is preferred over the static model. The persistence of fiscal variables can be explained by the relative stability of major expenditure and revenue categories. It is unlikely that public expenditure categories such as pensions and health care will experience major changes in the short and medium run. Also, public revenues based on the value added tax and income tax revenues depend directly on the wages and overall economic activity, which are proven to be highly persistent. Employing the static model, the valuable information emanating from the lagged value of dependent value is neglected, while the dynamic model allows for the modeling of a partial adjustment mechanism. Moreover, including lagged values of dependent variable on the right hand side of the equation may be crucial for obtaining consistent estimates of other parameters even though the autoregressive coefficient is not of direct interest (Bond, 2002). The linear dynamic model takes the form of:

$$y_{i,t} = \mu + \gamma y_{i,t\text{-}1} + \beta x_{i,t} + \alpha_i + \varepsilon_{i,t} \tag{1}$$

where i denotes number of each observation ($i = 1,\ldots.,$ N) and t denotes time periods ($t = 1,\ldots,$ T). The dependent and independent variables are represented by y and x, and β is a vector of parameters of interest. It is assumed that errors ε are identically and independently distributed over time and individuals with mean value 0 and constant variance. The parameters α_i are unobserved individual-specific time-invariant effect which allows for heterogeneity across the individuals. Since the lagged value of the dependent variable $y_{i,t\text{-}1}$ is serially correlated with α_i, the ordinary least squares (OLS) estimator is biased and inconsistent even when N tends to infinity and T is kept fixed (Nickell, 1981). By taking the first differences, the individual-specific effects are eliminated from the equation, which gives:

$$y_{i,t} - y_{i,t\text{-}1} = \gamma\,(y_{i,t\text{-}1} - y_{i,t\text{-}2}) + \beta\,(x_{i,t} - x_{i,t\text{-}1}) + (\varepsilon_{i,t} - \varepsilon_{i,t\text{-}1}) \tag{2}$$

However, the OLS method would still produce inconsistent estimates because the autoregressive term and disturbance measurement, which is now a first-order moving average (MA) process, are serially correlated through $y_{i,t\text{-}1}$ and $\varepsilon_{i,t\text{-}1}$. Anderson and Hsiao (1981) were the first to propose the estimation technique for dynamic models, where the term $(y_{i,t-1} - y_{i,t-2})$ is instrumented either with the second lag of level $(y_{i,t-2})$ or the second difference of the dependent variable $(y_{i,t-2} - y_{i,t-3})$. The two-stage-least-squares (2SLS) estimator obtained is unbiased as the instruments are correlated with $y_{i,t-1} - y_{i,t-2}$ but uncorrelated with the disturbance term in (2). However, using the second lag of level has the advantage over differences as it requires only two time periods, unlike the other instrument which requires at least three time periods. Moreover, Arellano (1989) shows that using lagged values is preferable because it does not induce a singularity problem and results in smaller variance in parameter values.

In this paper we employ the generalized method of moments (GMM) estimator, developed by Holtz-Eakin et al. (1988), later fashioned and improved by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). These estimators are designed for dynamic models with datasets where T is fixed and N tends to infinity, and they also address the problem of endogeneity of explanatory variables. Arellano and Bond (1991) argue that the first-difference GMM estimator is more efficient than the Anderson-Hsiao estimator due to the fact that it exploits additional restrictions on the covariance between regressors and the error term (moment restrictions). It is important to emphasize the initial assumption of no serial correlation in the errors. To demonstrate the mechanism of first-difference GMM estimator, let us observe the relationship (2) in t=3 as the first period:

$$y_{i,t-3} - y_{i,t-2} = \gamma\,(y_{i,t-2} - y_{i,t-1}) + \beta\,(x_{i,t-3} - x_{i,t-2}) + (\varepsilon_{i,t-3} - \varepsilon_{i,t-2}) \tag{3}$$

where y_{i1} is a valid instrument as it is correlated with $(y_{i,t-2} - y_{i,t-1})$ and not interrelated with $(\varepsilon_{i,t-3} - \varepsilon_{i,t-2})$. Following the same logic for the period t=4, we can use both $y_{i,2}$ and $y_{i,1}$ as instruments. If we further expand, it can be observed that at T, all valid instruments for $(y_{i,t-2} - y_{i,t-1})$ are the lagged values of dependent variable in levels $(y_{i1}, y_{i2}, \ldots, y_{T-2})$.

In this paper we use the system-GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) because of its high efficiency compared to the first-difference GMM, as lagged levels are poor instruments for the differences in the first-difference GMM estimator if the variables are highly persistent. System-GMM estimator imposes additional restrictions on the initial conditions process, which allows the introduction of more moment conditions. In the end, it creates a system of two equations – an equation in levels where lagged differences are valid instruments and an equation in first differences with lagged values as instruments.

We choose to use the one-step system-GMM instead of the two-step version, due to the fact that the asymptotic standard errors of two-step system-GMM are severely downward biased in the case of heteroskedasticity across individuals or non-normality (Blundell and Bond, 1998). Even though Windmeijer (2005) suggested variance correction, which leads to more precise inference, Monte Carlo simulations show a small efficiency gain in using a two-step system-GMM over a one-step version (Bond et al., 2001; and Soto, 2009). In addition, we present robust standard errors which are consistent in the case of heteroskedasticity and autocorrelation within panels. The final specification of dynamic model estimated with a one-step system-GMM will be the subject of several robustness checks.

Arellano and Bond (1991) proposed m_1 and m_2 statistic which test for the first-order and second-order serial correlation in the residuals. We can expect the presence of a first-order serial correlation in the error term; however the GMM estimator is consistent if there is no second-order serial correlation in the error term of the first-differenced equation. Hence, a model is well-specified if the null hypothesis is rejected for m_1 and not-rejected for m_2.

Since the Sargan (1958) test statistic is not robust in case of heteroskedasticity, the Hansen (1982) J-test statistic of over-identifying restrictions will assess the validity of the instruments. If Hansen's test indicates non-rejection of the null hypothesis, moment conditions are valid and the crucial assumption of GMM that all instruments are exogenous is satisfied. However, the Hansen test tends to become weak as the number of moment conditions grows, which gives rise to the problem of instrument proliferation, a topic expanded in the following section.

6.3 EMPIRICAL MODEL AND RESULTS

In order to examine the impact of demographic transition on the fiscal variables, an empirical model similar to the one specified by Callen, Batini and Spatafora (2004) and later replicated in Yoon, Kim and Lee (2014) is used. The model specification is:

$$Y_{i,t} = \alpha_i + \gamma Y_{i,t\text{-}1} + \beta Demo_{i,t} + \delta Z_{i,t} + \varepsilon_{i,t} \qquad (4)$$

with Y representing one of the fiscal variables and their lagged values, *Demo* is the set of demographic variables capturing population aging and Z is the matrix of control variables. Variable ε is the disturbance term, assumed to be independently and identically distributed with mean value 0 and constant variance. Subscripts i and t denote the country and the time period, respectively. All variables are expressed in percentages, except for real labor productivity and government effectiveness, which are denoted in logarithms.

Inclusion of lagged dependent variable enables us to differentiate between medium-term effects and long-run effects and allows for convergence among countries in shares of specific categories in total expenditure and overall size of public expenditure in GDP. Rewriting equation (4) yields:

$$\Delta Y_{i,t} = \alpha_i + (\gamma - 1)\, Y_{i,t\text{-}1} + \beta Demo_{i,t} + \delta Z_{i,t} + \varepsilon_{i,t} \qquad (5)$$

In equation (5), conditional convergence is observed through the coefficient on the lagged dependent variable. If γ is smaller than one, conditional convergence among countries occurs as those countries closer to their steady state levels of public expenditure experience a decrease in the public expenditure growth rate. In all empirical models, the autoregressive coefficient γ is smaller than 0, therefore conditional convergence is confirmed. Furthermore, equation (5) enables the separation of medium-run effects from long-run effects. While medium-run impact is captured by coefficient β, the long-run impact is calculated as $\beta/(1-\gamma)$. This implies that the greater the parameter of persistence (γ), the higher is the long-run effect of the explicative variable on left-hand side variable.

In the process of estimating the dynamic model with system GMM estimator, it is important to address the issue of the endogeneity of explanatory variables, since misspecification will produce biased and inconsistent estimates. One example is the correlation of an autoregressive term with a measurement error, thus the lagged dependent variable is considered to be predetermined. Predetermination implies that the current error term is not correlated with present and past values of the variable, but allows for correlation with future values. In the case of predetermined variables, valid instruments for difference equation are levels dated t-1 and further, while for level equation contemporaneous differences.

Except for the autoregressive term, all explanatory variables will be treated as endogenous. Hence, valid instruments for the difference equation are levels dated from t-2 onwards, whereas differences in t-1 are valid instruments for level equation. Since the unit of time in the panel dataset is a 4-year average, it is reasonable to assume reverse causality between explanatory and explained variables. While considering economic control variables as endogenous is not an issue, since there is simultaneity even in the shorter period than 4 years with explained variable, special attention is given to justification of considering demographic variables as endogenous in the model.

Most of the literature that has investigated the impact of demographic variables on economic variables, or included them as control variables to account for demographic trends, has considered dependency ratios as exogenous. While this assumption may hold if the time dimension consists of consecutive years or quarters, in the medium-run framework it may lead to unreliable estimates. Let us observe two such examples.

Firstly, a government decides to increase the birth rate and it implements a package of policies aimed at providing birth incentives. Such policies are manifested through increase in social protection expenditure (specifically family and child benefits) or public education expenditure. As a response, couples that otherwise would not decide to raise another child, due to the relative decrease in the child raising cost, change their minds. While these measures might not increase the birth rate in the first year, improvement is possible in the second or third year, which is still in the 4-year interval used in this research.

Secondly, net migration affects both OADR and YADR. Due to economic or political reasons, a country experiences net emigration with emigrants mostly in the fertile age. This reduces both dependency ratios instantaneously in the origin country (since the relative size of elderly and young population increases) and there are consequent changes in the destination country.

The endogeneity of demographic variables was already pointed out by Klein (1990), who argued that, in short-run cyclical models, demographic variables may be roughly considered exogenous, but otherwise it is a poor assumption. Furthermore, he stresses the necessity of including demographic variables in the endogenous category for further research. Unfortunately, most empirical work to date has not followed this recommendation.

It is well known that the first-differenced and system GMM estimators produce instruments which may overfit instrumented variables. As a consequence, estimated coefficients are biased towards the fixed effects estimator and OLS (Roodman, 2009). One of the indicators of instrument proliferation is the perfect p-value of 1 for the Hansen statistic. To overcome instrument proliferation, we employ command *collapse* which reduces the number of moment conditions, resulting in one instrument for each lag distance and 0 as substitution for missing values.

All estimations are computed in econometric software Stata 14.1 using the command *xtabond2* created by Roodman (2009).

Before proceeding with the empirical findings, one should stress that the results may depend on the econometric technique used in data examination. Nagarajan et al. (2016) provide a vast survey of theoretical and empirical studies examining the impact of an aging population on economic growth, with public finance as one of the three channels between population aging and growth. According to their results, the most frequent econometric methods, such as OLS, simulation and panel data, are likely to lead to negative correlation. On the other hand, the use of a dynamic generalized method of moments and other methods more likely generates a positive or no effect.

Results of model estimations are summarized in tables 2, 3, 4, 5 and 6. The fixed effects estimator produces a downward-biased estimate of the autoregressive coefficient while OLS generates an upward bias. A consistent estimate of the autoregressive term in dynamic models estimated with system-GMM should lie between FE and OLS. Therefore, we report the results using all methods. Hausman test checks appropriateness of the random-effects estimator. If the null hypothesis is rejected, as in all our models, the fixed effects estimator is more suitable. The main results are obtained using system-GMM estimator, hence they will be interpreted.

Table 2

Estimates of the old-age pension expenditure dynamic model

	FE	Pooled-OLS	System GMM
Lagged dependent variable	**0.521***** (0.099)	**0.908***** (0.072)	**0.835***** (0.157)
Old-age dependency ratio	**0.277***** (0.052)	0.049 (0.048)	**0.174***** (0.050)
Young-age dependency ratio	0.009 (0.060)	0.015 (0.058)	0.103 (0.064)
Log (Government effectiveness)	**-0.902**** (0.351)	-0.263 (0.286)	-0.182 (0.488)
Log (Real labor productivity)	1.755 (1.435)	-0.319 (3.336)	2.381 (2.100)
Unemployment	**0.107***** (0.028)	-0.026 (0.062)	**0.093***** (0.034)
Trade openness	-0.009 (0.007)	-0.004 (0.005)	0.003 (0.009)
Net migration	-0.016 (0.019)	0.016 (0.037)	**0.046**** (0.021)
Constant	-10.715 (6.903)	1.613 (15.131)	**-17.140*** (9.205)
Observations	80	80	80
Groups	24	24	24
R^2	0.742	0.909	–
Hausman test	27.62***	–	–
Instruments	–	–	32
m1 test	–	–	0.020
m2 test	–	–	0.472
Hansen test	–	–	0.945

*Notes: ***, ** and * denote rejection of null hypothesis at 0.01, 0.05 and 0.1 respectively. Standard errors are in parentheses. R^2 is the coefficient of determination. Number of observations and groups is reported for all estimation methods, with addition to number of instruments for system-GMM. P-values of m1 and m2 test of first and second-order correlation are presented, as well as the p-value of Hansen test.*

Source: Author's calculations.

Estimation results for pension expenditure can be seen in table 2. Parameter estimate of the autoregressive term is significant and has a value relatively close to 1 which implies a strong persistence of pension expenditure. Among the explanatory variables, parameter estimates of OADR and unemployment are significant at the 0.01 level, whereas the standardized coefficient of migration is significant at the 0.05 level.

OADR is expectedly the biggest determinant of pension care expenditure both in the medium run and the long run. In the medium run, a one-percentage point increase of OADR raises pension care expenditureby 0.17 percentage points while in the long-run this parameter rises up to 1.04. Unemployment has a positive impact on pension expenditure as a higher unemployment rate gives an incentive for early retirement to eligible unemployed people. Those are primarily the oldest cohort of the unemployed with a relatively low possibility of finding jobs compared to the unemployed aged from 25 to 45. In the long run, the estimate of standardized coefficient is 0.555. Regarding migrant flows, a one unit increase in the crude migration rate is robust and positive with value 0.046.

TABLE 3
Estimates of the social protection expenditure dynamic model

	FE	Pooled-OLS	System GMM
Lagged dependent variable	0.138 (0.110)	**0.937***** (0.040)	**0.721***** (0.091)
Old-age dependency ratio	**0.192**** (0.094)	0.035 (0.055)	**0.227**** (0.098)
Young-age dependency ratio	-0.022 (0.130)	0.065 (0.059)	0.121 (0.156)
Log (Government effectiveness)	**-1.622**** (0.690)	**-0.610*** (0.341)	0.539 (1.020)
Log (Real labor productivity)	2.513 (2.749)	-6.611 (4.210)	4.206 (3.353)
Unemployment	**0.228***** (0.062)	-0.041 (0.060)	**0.143**** (0.057)
Trade openness	-0.003 (0.015)	-0.004 (0.005)	0.006 (0.013)
Net migration	-0.047 (0.043)	**0.124**** (0.052)	**0.102*** (0.060)
Constant	-2.898 (13.710)	29.624 (19.239)	-24.856 (16.283)
Observations	91	91	91
Groups	24	24	24
R^2	0.590	0.805	–
Hausman test	57.79***	–	–
Instruments	–	–	24
m1	–	–	0.047
m2	–	–	0.201
Hansen test	–	–	0.425

Note: See note on table 2.
Source: Author's calculations.

Table 3 contains results for a dynamic model of social protection expenditure. As in case of pension expenditure, the same explanatory variables – unemployment, net migration and OADR – are robust and they exert a positive impact on social protection expenditure. Since social protection expenditure is less persistent than pension expenditure, the long-term effect of significant variables is relatively smaller.

The medium-run impact of OADR is relatively high compared to table 2, bearing in mind that social protection expenditure comprises more categories available for the elderly population. The same reasoning is applicable to the migration rate, as immigrants have a relatively higher number of benefits available. Negative influence of elderly population on social welfare confirms the findings of Lusky and Weinblatt (1998), and Labrador and Angona (2003). Changes in the young population do not significantly affect the level of social protection expenditure.

Table 4

Estimates of the health expenditure dynamic model

	FE	Pooled-OLS	System GMM
Lagged dependent variable	**0.551***** (0.120)	**1.041***** (0.054)	**0.858***** (0.127)
Old-age dependency ratio	0.049 (0.049)	0.005 (0.021)	0.046 (0.038)
Young-age dependency ratio	-0.018 (0.059)	**0.038*** (0.021)	**0.132**** (0.060)
Log (Government effectiveness)	-0.388 (0.322)	-0.094 (0.118)	-0.466 (0.653)
Log (Real labor productivity)	0.242 (1.256)	0.708 (1.574)	**2.939**** (1.468)
Unemployment	0.015 (0.028)	-0.029 (0.022)	-0.031 (0.045)
Trade openness	0.001 (0.007)	-0.0002 (0.002)	-0.005 (0.005)
Net migration	0.001 (0.020)	-0.009 (0.019)	-0.008 (0.026)
Constant	0.806 (6.276)	-3.926 (7.194)	**-15.722**** (7.137)
Observations	91	91	91
Groups	24	24	24
R^2	0.713	0.919	–
Hausman test	18.68**	–	–
Instruments	–	–	24
m1	–	–	0.051
m2	–	–	0.725
Hansen test	–	–	0.322

Note: See note on table 2.

Source: Author's calculations.

The results for HCE are reported in table 4. Significant determinants of health expenditure are YDR and real labor productivity, while an increase in the elderly share does not affect the level of HCE. A one-percent rise in productivity increases health care expenditure by 2.94 percentage points. The dominant effect of productivity on HCE is in accordance with previous literature attributing to productivity the role of main determinant of health expenditure developments. Counter-intuitively, the expenditure is not affected by the share of elderly population whereas an increase in young population raises it by 0.13 percentage point. The latter confirms U-curve representing relationship between HCE and age groups, as the expenditure for health care is higher for young population compared to the middle-aged population.

Table 5
Estimates of the total government expenditure dynamic model

	FE	Pooled-OLS	System GMM
Lagged dependent variable	0.011	**0.850*** **	**0.519*** **
	(0.112)	(0.051)	(0.120)
Old-age dependency ratio	**0.390***	0.026	**0.501** **
	(0.217)	(0.097)	(0.208)
Young-age dependency ratio	-0.062	0.099	0.034
	(0.312)	(0.102)	(0.305)
Log (Government effectiveness)	**-3.607***	-0.662	1.967
	(1.606)	(0.572)	(2.251)
Log (Real labor productivity)	1.986	10.344	5.236
	(6.359)	(7.337)	(6.188)
Unemployment	**0.379** **	-0.122	**0.315** **
	(0.143)	(0.103)	(0.124)
Trade openness	-0.019	-0.003	0.004
	(0.035)	(0.009)	(0.028)
Net migration	-0.158	0.049	**0.319***
	(0.100)	(0.089)	(0.172)
Constant	27.032	-41.838	-18.788
	(31.747)	(33.334)	(31.378)
Observations	91	91	91
Groups	24	24	24
R^2	0.434	0.750	–
Hausman test	90.83***	–	–
Instruments	–	–	31
m1	–	–	0.027
m2	–	–	0.370
Hansen test	–	–	0.429

Note: See note on table 2.

Source: Author's calculations.

As can been seen from table 5, the overall characteristics of public expenditure model are similar to those of the pension model and the social protection model. However, the main difference is the degree of persistence captured by the parameter γ in the model which is in this model the lowest with the value estimate of 0.501. Thus, the long-term effect of relevant explicative variables is of relatively smaller magnitude. The parameter estimate for OADR is significant at the 0.05 level and positive. In the medium run, a one percentage point increase in OADR increases total public expenditure by 0.50 percentage points.

Coefficients for unemployment and net migration have values of 0.315 and 0.319 at the 0.05 level and 0.1 level respectively. Since parameter estimates of unemployment and net migration are positive and quite similar, a country that faces net emigration can offset the negative influence from medium-run unemployment. However, the parameter of YDR is insignificant, which implies that the rise of the youth population with respect to the working-age population does not produce any upward or downward pressure on total government expenditure. In a similar manner, trade openness, labor productivity and estimate of government effectiveness are not significant determinants.

The results for total government revenue are displayed in table 6. The autoregressive coefficient with the value 0.757 is higher than in public expenditure which indicates a relatively larger degree of persistence. The impact of net migration and OADR is positive and significant at the 0.01 and 0.05 level respectively. An increase in the elderly population changes positively both public expenditure and public revenue. However, this impact is lower in the case of public revenues and thus overall change in the budget balance is negative, which confirms the results of Callen, Batini and Spatafora (2004), and Hondroyiannis and Papapetrou (2008). It should be noted that results for net migration hold if total population is held constant, since we do not introduce it in the models.

TABLE 6
Estimates of the total government revenue dynamic model

	FE	Pooled-OLS	System GMM
Lagged dependent variable	**0.213**** (0.102)	**0.933***** (0.036)	**0.757***** (0.037)
Old-age dependency ratio	**0.281**** (0.119)	0.034 (0.082)	**0.326***** (0.082)
Young-age dependency ratio	-0.178 (0.132)	-0.009 (0.080)	0.134 (0.162)
Log (Government effectiveness)	1.118 (0.893)	-0.520 (0.421)	1.177 (0.936)
Log (Real labor productivity)	-4.283 (3.473)	2.071 (5.777)	4.277 (3.346)
Unemployment	**0.171**** (0.074)	**-0.171**** (0.075)	0.012 (0.057)
Trade openness	0.001 (0.019)	-0.005 (0.006)	0.003 (0.015)
Net migration	0.078 (0.054)	0.035 (0.071)	**0.120**** (0.050)
Constant	**48.781***** (18.402)	-5.143 (25.492)	-20.824 (16.669)
Observations	94	94	94
Groups	24	24	24
R^2	0.671	0.930	–
Hausman test	61.20***	–	–
Instruments	–	–	32
m1	–	–	0.013
m2	–	–	0.828
Hansen test	–	–	0.805

Note: See note on table 2.

Source: Author's calculations.

7 CONCLUSION

Population aging is a demographic process characterized by a relative increase in the elderly population and longevity accompanied with a decrease in the fertility rate. The demographic projections for the EU made for the period 2013-2060 estimate a rise in total fertility rate but below the natural replacement rate, while a significant increase is expected for longevity of both men and women. As result, in the period from 2013 and 2060 old-age dependency ratio and young-age dependency ratio are expected to increase on average by 92.89% and 13.32% respectively. Budgetary projections of the demographic impact anticipate an increase of public health care expenditure in all countries by an average of 24.07% with respect to the level in 2013. On the other hand, a minor increase in the average pension expenditure is predicted as the main positive factor contributing its growth – increase in OADR – is offset by other components as a result of legislative reforms regarding the public pension system.

The exact impact of population aging on an economy is a subject of debate among economists since there is no unanimous opinion on how it affects GDP per capita, savings and inflation. Previous research, both overlapping generations (OLG) model simulations and other empirical work investigating the fiscal implications of demographic aging argue for a positive impact of aging on total public expenditure and the budget balance. This paper amends the findings of previous literature considering demographic variables endogenous, therefore allowing reverse causality with the fiscal variables.

The dataset consists of observations for 25 EU countries over the 1995-2014 period. In order to obtain the medium-run dynamics, we use a 4-year average resulting in 5 time observations. The dependent variables in the models are public revenues, the selected categories of government expenditure and its overall size. The explanatory variables are a set of demographic variables representing population aging and a group of control variables. Coefficient estimates for the old-age and the young-age dependency ratios are in the focus of this paper. The control variables are unemployment rate, real labor productivity, estimate of government effectiveness, trade openness and crude net migration rate. All right hand side variables, with the exception of the lagged dependent variable, are considered endogenous thus valid instruments are levels dated t-2 and further on.

The most appropriate estimation method for dynamic models, for datasets where T is small and N is large, is the Generalized Method of Moments. We employ the one-step system-GMM developed by Blundell and Bond (1998) for estimation of dynamic models. Final results report standard errors robust on any pattern of heteroskedasticity within individuals. Robustness of all results, which consists of testing for correlation in the residuals and validity of instruments, is satisfied.

The results for the impact of population aging on budget deficit and old-pension expenditures are in line with previous research, whereas they are at variance with earlier results that consider the share of the elderly population to be a determinant of health care expenditures. They indicate a significant and positive influence of population aging on expenditure for the public pension system and overall social protection. Furthermore, since the positive impact on overall public expenditure is higher than on the total government revenues, the increase in the elderly share is negatively correlated with budget balance. On the other hand, increase in young population is significant only in the health expenditure dynamic model, where it exerts a positive impact, but substantially smaller that of real labor productivity, which is the main determinant of health expenditure. Concerning control variables, unemployment and net migration increase social protection expenditure, and pension expenditure as their subgroup, as well as the overall public expenditure. Net emigration caused by economic circumstances, characteristic of Central and Eastern Europe, might not have negative impact *per se* on public expenditure since it decreases the pressure on expenditures for pension and social protection.

In the process of determining medium-term budgetary frameworks, governments should bear in mind demographic developments. The empirical findings support the need for policy measures aimed at mitigating the impact of population aging. These policies can take the form of active labor market policies with the goal of increasing labor force participation and employment, or legislative reforms which delay entrance in retirement, through penalization of early retirement and stricter criteria for eligibility, and incentives for employment above the threshold age. On the methodological side, we emphasize the importance of considering demographic variables endogenous in economic models, since they are determined by present economic developments, among others public finance.

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