DALARNA UNIVERSITY

Degree Project

Master's Thesis

To what extent do Demographic changes affect Pay-As-You-Go Pension Systems?

Using the fixed effects regression model with panel data on 20 OECD countries from 1991 to 2017

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Abstract

This thesis investigates the effect of demographic changes on the pay-as-you-go (PAYG) pension system. Demographic changes specifically refer to increasing life expectancy and decreasing fertility rates. An increase in life expectancy leads to a rise in the number of pensioners. A decrease in the fertility rate leads to a smaller population financing future PAYG pension payments. Thus, this thesis investigates the extent of the effect of demographic changes on the PAYG pension system and to know if these effects are negative or positive. Based on panel data for 20 Organisation for Economic Co-operation and Development (OECD) countries for the years 1991 to 2017 and using the fixed effects regression model, the effects of life expectancy and fertility rate on PAYG pension expenditure are estimated. It is found that increasing life expectancy adversely affects the PAYG pension system. However, the result obtained for fertility rate shows that it has no statistically significant effect on the PAYG pension system.

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1. Introduction

Pension systems are a form of consumption smoothing whereby individuals reallocate their consumption over their lifetime, which is one of the objectives of any country's welfare system. Most states or governments worldwide mainly use the pay-as-you-go system of organizing pensions to provide social welfare to their retired population. The pay-as-you-go system, abbreviated as PAYG, operates such that the government claims a certain percentage from the income of the working people to pay for the pension benefits of the retired population. Pension finance worldwide faces the problem of demographic changes. These demographic changes mainly derive from an overall increase in life expectancy, which increases the total population and the number of pensioners per worker. Decreasing fertility rate is the other demographic factor that reduces the labor force that follows the current labor force contributing to pension benefit payments (Barr, 2020).

Increasing life expectancy directly means that pension payments will be paid for longer years to individuals since they will live longer. The declining fertility rate means that the current working population, financing the current cost of pension benefits, will face a smaller working population to invest their pension payments when they retire. According to the World Bank (2022), the fertility rate for the world in 2019 was 2.415 total births per woman, and the life expectancy for the world was 72.574 years for a newborn. This fertility rate is if prevailing mortality patterns at the time were to remain the same throughout the newborn baby's life. The fertility rate thus decreased from 3.249 in 1990, and life expectancy increased from 65.433 in 1990.

Both demographic factors have been trending in the direction where they have become a cause for concern for states operating the PAYG pension system. Life expectancy keeps trending upwards, and the fertility rate keeps trending downwards. With the PAYG system of organizing pensions, usually run by the state, there is redistribution across generations. A worker's entitlement to pension benefits leans on a promise in the nation's social security laws (Barr, 2020). The old-age dependency ratio keeps increasing, putting enormous pressure on the current working population to finance pension benefit payments. The majority of the literature written on this topic, such as Alili et al. (2018), Casamatta and Gondim (2011), Chai and Kim (2018), Kit (2015), Schon (2020), and Tabata (2015), are primarily based on the use of economic theory in explaining how life expectancy and fertility rate affect the PAYG pension system.

According to economic theory, increasing life expectancy and declining fertility rates negatively impact the PAYG pension system. Thus, this paper investigates how these demographic changes affect the PAYG pension system. The findings are expected to help OECD policymakers know which demographic factors to focus on when implementing PAYG pension reforms. A statistical model, specifically the fixed effects regression model, is used in my empirical framework. My analysis focuses on the use of panel data on 20 OECD countries from 1991 to 2017. My paper contributes to the literature by providing estimates of the effects of life expectancy and fertility rate on PAYG pensions for 20 OECD countries using an econometric technique. As far as I know, my paper is the first to use an econometric approach to estimate the effects of these demographic changes on the PAYG pension system within OECD countries. My analysis is essential for formulating future PAYG pension reforms and determining which demographic change to focus on when tackling how it affects the PAYG pension system.

To the best of my knowledge, no previous studies have employed either cross-sectional or panel data that focuses on OECD countries. Neither has any prior study used an econometric technique in investigating this topic. Most of these previous studies, such as Chai and Kim (2018), Kruse and Nyberg (2004), and Tabata (2015), use the OLG model in their analysis which does not use specific country data or periods. Thus, my study is the first to attempt to use detailed country data and timeframe to investigate the effects of demographic changes on the PAYG pension system.

The remainder of this paper is structured as follows. Section 2 provides a literature review, and section 3 presents the analytical framework for this research paper. Section 4 details the data, sources, and the econometric model and discusses the fixed and random effect models. Section 5 shows and describes the results of my analysis, while section 6 discusses the results obtained. Finally, section 7 concludes this research paper.

2. Literature Review

This section reviews previous literature on the effects of demographic changes on the PAYG pension system. Most of the studies I have come across employ the Overlapping Generations Model (OLG), which they use as a theoretical representation to show the effects of demographic factors on the PAYG pension system. The OLG model does not use specific country data or periods. Thus, the papers using this model do not deal with particular countries or periods. Other studies, such as Alili et al. (2018) and Kontis et al. (2017), provide forecasts of future trends for these demographic factors within OECD countries using country-specific data and periods.

The OLG model is mainly used to analyze the macroeconomic effects of different forms of pension systems. Tabata (2015) uses the OLG model to show that in economies with a high old-age dependency ratio and large pensions, reforms that move from the defined benefit system to the defined contribution system affect the economies positively. Tabata (2015) shows this by using assumptions with no specific country data or period specified. He employed a two-period OLG model with PAYG pension systems. From his assumptions, he derived the model, which gave two results. The model implied that population aging is triggered by either a decrease in the population growth rate or an increase in the old age survival probability. From his research, he finds that when life expectancy is high, and the size of pension payments is significant under the defined-benefit scheme, the transition from that scheme to a defined contribution scheme negatively affects the overall size of the PAYG pension system. This result is in line with Kit (2015), who mentions that economies that implement reforms to change their pension structure to the defined contribution would experience negative changes to their PAYG pension system.

Alili et al. (2018), using the basic ARIMA model, write about the sustainability of the pension system in the Republic of Macedonia. Alili et al. (2018) present a forecast of individual regressors using the basic ARIMA model. They use time series data on financial and demographic characteristics of the Macedonian population from 1994 to 2016. Their regression forecasts that the employed per pensioner ratio will decrease to 1.27 by 2056, compared to 1.9 in 2016. Their forecasts showed that there would be a 51.8 percent increase in the population of pensioners. For the people of the working age, there will be a 28.5 percent increase which is a lower increase than the pensioners. According to Alili et al. (2018), the main issue of many developed and transitional countries is precisely the direction of the development of their pension systems. Alili et al. (2018) mention that due to changes in demographic structure, difficulties were encountered in implementing the principle of solidarity between generations. Demographic structure changes resulted from the average human life expectancy increase and a reduced employed-retired ratio. Alili et al. (2018) use these forecast results to explain that reforms need to be implemented in The Republic of Macedonia. Their forecast results align with the result shown by Kontis et al. (2017). They also provide future forecasts of these demographic factors using a developed ensemble of 21 forecasting models, probabilistically contributing to the final projections. Their model has thirty-five countries, including Australia, France, Greece, Japan, Macedonia, South Korea, Sweden, Switzerland, and the USA. They concluded that their projections show continued increases in life expectancy, and thus there is a need for careful planning of pension systems going forward.

Chai and Kim (2018) contribute to this literature by studying the effect of demographic changes on the public PAYG pension system. They use a three-period OLG model with the public PAYG pension system. Their OLG model assumes that economic agents live for three periods: as children, workers, and pensioners. They use analytical solutions from this simple model to compare steady states with different life expectancy and fertility rates. The Cobb-Douglas function gives the production in their model. They find that higher life expectancy and pension payments increase public PAYG pension spending in the steady state equilibrium. A lower fertility rate decreases general savings since fewer workers contribute taxes relative to the number of retirees. Significantly, the effect of lower fertility rates on the public PAYG pension spending was indeterminate. This conclusion is in line with the conclusion drawn by Fanti and Gori (2012). They find that the fertility rate will not affect PAYG pensions in the long run. Fanti and Gori (2012) also use the OLG model in their research paper and come to a similar conclusion. Countries used by writers such as Alili et al. (2018) and Kontis et al. (2017) are thirty-five countries within the OECD. Thus, my paper focuses on pension systems within OECD countries using country-specific data in running regressions to investigate more on the effects of these demographic changes on the PAYG pension system.

3. Analytical Framework

This section takes an analytical approach to explain how pension systems, in general, operate. It starts by explaining the known forms of pension systems available, followed by details of how the PAYG pension system receives funding. Presented next are the two main demographic factors. Subsequently, there is a discussion on other factors that affect the PAYG pension system, and the section ends by providing details of the OLG model.

3.1 General Forms of Pension Systems

Pension systems, in general, are organized using two primary forms: the pay-as-you-go system and the fully funded system. The fully funded pension system generally operates such that individuals create a pension fund account. Contributions from every member go into their pension fund account. Assets purchased on their behalf accrue interests, and these interests add to their contributions. The fully funded pension system gives the individual who attains the retirement age set by the state the total of all the contributions plus interests made over their working life. It is then paid to the individual by the form of their choosing, in an annuity form, or they can choose to take everything at once immediately after hitting that retirement age. A fully funded pension system works such that an individual receives what they have contributed, and thus there is no redistribution across generations (Barr, 2020). The fully funded pension system provides a great incentive for individuals to work because this system creates a direct relationship between an individual's contribution and the pension benefit to be received in retirement (Castanheira and Galasso, 2011).

The PAYG pension system, which is my research paper's central system of interest, differs from the fully funded pension system. With the PAYG system, there is redistribution across generations. This redistribution is because the currently employed population finances the pension benefits received by the current, retired people. When the presently employed population retires, funding of their pension benefits falls on the employed population that comes after them. The state mainly operates the PAYG pension system, and contributions come from taxing the current working population to finance the pension payments of the present retired population. PAYG and fully funded pension schemes have different forms of relating contributions to pension benefits. They are in three other formats: defined-contribution schemes, defined-benefit schemes, and notional-defined contribution schemes.

3.2 Financing the PAYG Pension System

Financing the PAYG system is through the compulsory contributions made by the working population. It means contributions from both employers and employees. The PAYG pension system only pays pensions directly from contribution payments (Kune, 2001). The rate of contribution per individual differs from country to country. Each actively working individual has taxed a certain percentage of their monthly salary, and the state receives this. Based on the system's structure in various countries, the individual and their employer share the total contribution paid. This amount received by the state goes to pay for the monthly pension benefits of the retired population. Thus, there is a direct relationship between current pension contributions and pension payments for the PAYG pension system.

Taking one country, such as the Czech Republic, the PAYG pension system with defined benefits is used to finance the state pension, and the Czech Social Security Admission is in charge of administering it (Tapia, 2008). In Poland, the public pension system is compulsory and uses PAYG financing. The state-owned Social Insurance Institution runs this public pension (Tapia, 2008). In Poland, 12.2% of an individual’s taxable income goes into the publicly managed PAYG pension system (Tapia, 2008). Of that, 9.7% comes from the employer, and 2.47% comes from the worker (Tapia, 2008). The total contributions are channeled to the Social Insurance Institution and distributed to the various pension funds (Tapia, 2008). The Netherlands' statutory social security pension system uses the PAYG financing system. According to Tapia (2008), the employer and employee contribute in the Netherlands. In 2015, the employer contributed 10.5%, and the employee contributed 5.3% (Tapia, 2008).

3.3 Demographic Factors

Life expectancy is the crucial metric for accessing population health, capturing the mortality along an individual's life course, and telling us the average age of death in a population (Roser et al., 2013). According to the World Bank (2022), life expectancy increased by approximately 5.2 years from the year 2000 to the year 2019. Rising life expectancy means the pensioners’ population is also growing since people live longer. Thus, the current working population will finance more pension benefit payments for these pensioners. Population aging, as a result of increasing life expectancy, is leading to an increase in the number of people in retirement to the number of the working-age population. It is also leading to an increase in the number of years people are spending in retirement. Rising life expectancy is a primary source of the financial difficulties facing social insurance systems in the United States and throughout the world (Reznik et al., 2006). Explaining how increasing life expectancy affects the PAYG pension system is straightforward. The increase in life expectancy increases the number of the population of pensioners compared to the people of working age. This working-age population finances pension payments to these pensioners and thus creates a problem of increasing dependency. Without reforms, the PAYG system will not be sustainable, and the state that usually runs a PAYG pension system will be in a deficit from financing these payments. According to Kit (2015), when the population is aging, and the rate of aging is higher than productivity growth, the total contribution cannot match the expenditure required to maintain the promised retirement benefits.

According to economic theory, the declining fertility rate is another demographic factor that impacts the PAYG pension system. "The total fertility rate (TFR) of a population is the average number of children that would be born to a woman over her lifetime if she were to experience the exact current age-specific fertility rates through her lifetime and she were to survive from birth through the end of her reproductive life" (Nargund, 2009, p.191). According to the World Bank (2022), the fertility rate for the world decreased from 2.696 total births per woman in the year 2000 to 2.402 total births per woman in 2019. The declining fertility rate leads to the current labor force being followed by a smaller one. Since the PAYG system redistributes across generations, the current working age, followed by a smaller working generation, directly affects the financing and payment of PAYG pension benefits. Bovenberg (2007) writes that whereas PAYG and fully funded forms of organizing pension systems are vulnerable to increased longevity, PAYG pension systems are especially vulnerable to lower fertility rates because it relies on the human capital of the young to finance the pensions of the older generation. It leads to the younger generation contributing more to fund the high pension benefit payments to the larger population of the older generation. Thus, with declining fertility rates, the financing of the PAYG pension system is not sustainable for future generations as the trends for fertility rates continue to decrease. These two demographic factors simultaneously make the sustainability of the PAYG pension system a significant issue for all countries operating this form of the pension system. An aging population from increasing life expectancy, and a reduction in future working-age population from decreasing fertility rate, are major demographic issues that need addressing concerning the PAYG pension system.

3.4 Other Factors that Affect PAYG Pensions

Other factors affect the PAYG pension system. Factors include contribution rate, retirement age, individual income, and replacement ratio. The replacement ratio measures how effectively the PAYG pension system provides a retirement income to replace income earned before retirement (OECD, 2022). For the state to maintain pension benefits, the pension contribution rates have to be increased, which puts a higher burden on the younger working population (Yasuoka, 2018). According to Clements et al. (2014) and Rotschedl (2015), changing socio-economic circumstances and attitudes impact the fiscal sustainability of PAYG pension systems. Socio-economic factors include evolving family structures, rising unmarried couples in advanced countries, and changing women's labor market role.

For PAYG pensions, the higher an individual's income, the higher their contribution. If the majority of the working population are low-income earners, the contribution received by the state from each individual will be small. Thus, this puts the PAYG pension system in a financial deficit because the contributions received will not be sufficient to finance the pension payments. It could lead to a reduction in pension benefit payments, which will cause the pensioners to be unable to maintain their standard of living through their retirement years. Changing the income structure of the economically active population can improve the sustainability of the PAYG pension system (Rotschedl, 2015).

Retirement age is another factor that affects the PAYG pension system. A state with a lower retirement age will mean individuals retire earlier and spend more time in retirement. If the retirement age is short, an individual will work fewer years and spend more years as a pensioner receiving pension benefits. Lower retirement age directly decreases the active working population and increases the retired population. This increase in the retired population affects the financing and payments of PAYG pension benefits. A state with a retirement age of 64 will have more pensioners to pay pension benefits to than a state with a retirement age of 66. A higher retirement age means individuals will work longer and reduce the retired population simultaneously.

3.5 The Overlapping Generations Model (OLG Model)

The OLG model accounts for complex economic interactions involving multiple generations. This model can predict essential variables such as rates of return on assets and outcomes of pension restructuring (Andrews et al., 2016). Writers such as D'autume (2003), Cipriani (2013), and Baksa et al. (2020) have made use of the OLG model in explaining how demographic changes affect the PAYG pension system. Specifically, the effect of increasing life expectancy and declining fertility rate on the PAYG pension system. Cipriani (2013) obtained a result that in the event of increased life expectancy, the OLG model with constant fertility shows that the effect is a decrease in PAYG pension benefits. In the event of increased life expectancy, the OLG model with endogenous fertility had a result of unfavorable influence on fertility and a negative impact on pension benefits (Cipriani, 2013). Majcen and Verbic (2007) used the overlapping generations' general equilibrium modeling to model the pension system within a dynamic general equilibrium framework. According to Majcen and Verbic (2007), the dynamic general equilibrium model they used in their paper is a better and more complete instrument for evaluating the socio-economic impact of both systems of organizing pensions.

4. Empirical Framework

Since my paper focuses on demographic changes, the independent variables in the econometric model are only demographic factors. This section begins by explaining the data used and detailing the econometric model. Data sources are presented together with the countries included and the years used. Following is a brief discussion of some selected descriptive statistics on the variables used in the dataset and the econometric model. This section concludes by explaining the fixed and random effects models, the two possible econometric techniques for my regressions.

4.1 Data and Econometric Model

Data for the dependent variable, PAYG pension expenditure, was extracted from OECD (2022) pension spending indicator. The World Bank Indicators (2022) collected all independent variables' data. Panel data collected for the regression is data on 20 OECD countries that operate the PAYG form of pension through their public pension system. The twenty countries included in the dataset based on the availability of data are Austria, Belgium, Canada, Czech

Republic, Denmark, Finland, France, Germany, Greece, Italy, Korea, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Switzerland, and Turkey. Data is from 1991 to 2017 for all 20 OECD countries on all four variables included. Variables used are PAYG pension expenditure, life expectancy in these countries, fertility rates for these countries, and the employment-to-population ratio. The equation for the econometric model is detailed below as:

$$ln\, payg_{it} = \beta_1 fertr_{it} + \beta_2 lifexp_{it} + \beta_3 empr_{it} + \alpha_i + u_{it} \qquad (1)$$

According to the OECD (2022), old-age cash benefits provide an income for persons retired from the labor market or guarantee incomes when a person has reached a standard pensionable age or fulfilled the necessary contribution requirements. The dependent variable ($ln\, payg_{it}$) in this model is public pension expenditure, defined by OECD (2022) as all cash expenditures (including lump-sum payments) on old-age and survivor's pensions, measured in percentages as a percentage of gross domestic product (GDP).

The World Bank (2022) defines life expectancy ($lifexp_{it}$) as an indicator of the number of years a newborn infant would live if prevailing patterns of mortality at the time of birth were to stay the same throughout its lifetime. The unit of measurement is total years.

Fertility rate ($fertr_{it}$), according to The World Bank (2022), represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children per age-specific fertility rate of the specified year. The unit of measurement is total births per woman.

Employment refers to working-age persons engaged in any activity to produce goods and services for pay or profit (The World Bank, 2022). The World Bank (2022) defines the employment-to-population ratio ($empr_{it}$) as the proportion of a country's employed population. The unit of measurement is in percentages as a percentage of the total population.

α_i denotes the unknown intercept for each entity (n entity-specific intercepts) in the model. This unknown intercept term captures omitted variables that are different across entities but fixed across time. u_{it} represents the error term in the econometric model. The error term captures omitted variables that vary across entities and over time. I perform the Durbin-Wu-Hausman test to determine if the fixed or random effects model is appropriate for my regression. I also conducted the modified Wald and Wooldridge tests to check for heteroskedasticity and autocorrelation.

4.2 Descriptive Statistics

Table 1 presents some selected descriptive statistics on the variables used in the econometric model.

Table 1. Variable descriptive statistics

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
PAYG	540	8.16	3.46	0.50	17.09
FERTR	540	1.61	0.31	1.05	3.02
LIFEXP	540	78.38	3.03	64.76	83.60
EMPR	540	54.44	6.88	37.74	67.55

Panel data has a cross-sectional component of 20 countries and a time series of 27 years. Combining the cross-sectional and the time series components gives 540 observations for each variable. From Table 1, the mean value of 78.38 for life expectancy shows that the average number of years people live is approximately 78. Life expectancy has a minimum of about 65 years. It has a maximum of about 84 years, which indicates that for these 20 OECD countries, individuals can live up to a maximum of about 84 years. The average fertility rate for these countries in the period used is approximately two total births per woman. The fertility rate has a minimum of approximately one total birth per woman and a maximum of approximately three total births per woman. It shows that every woman will have at least one child within their childbearing years. This statistic also indicates that each woman can have a maximum of 3 children within their childbearing years. On average, the employment-to-population ratio is approximately 54 percent of the total population for these 20 OECD countries. The average PAYG pension expenditure is approximately 8 percent of GDP. Within these 20 OECD countries, PAYG pension spending can be as low as 1 percent and as high as 17 percent of their total GDP.

4.3 Fixed Effects and Random Effects Models

Panel data models examine both cross-sectional groups and time-series effects. These effects could either be fixed or random. The fixed effects (FE) model explores the relationship between the dependent and independent variables within an entity and helps analyze the impact of variables that vary over time (Torres-Reyna, 2007). "When using FE, we assume that something within the individual may impact or bias the predictor or outcome variables, and we need to control for this" (Torres-Reyna, 2007, p.9). According to Torres-Reyna (2007), the fixed effects model is appropriate whenever the interest is in analyzing the impact of variables that vary over time. With the fixed effects model, the transformations that produce the observations in deviations from the individual means are termed the within transformation (Verbeek, 2017). The estimator β obtained from this transformation is called the within estimator or the fixed effects estimator (Verbeek, 2017). An advantage of the fixed effects model is that it allows controlling all time-invariant variables omitted from the model (Collischon and Eberl, 2020). This advantage generally relates to variables that are hard to measure or observe. Allison (2006) does say in his paper that a disadvantage of the fixed effects model is that it does not give estimates of the effects of variables that do not change over time. Another disadvantage of the fixed effects model is that its estimates may have substantially larger standard errors leading to high p-values.

The random effect model is an alternative model used for panel data. "The rationale behind the random effects model is that, unlike the fixed effects model, the variation across entities is assumed to be random and uncorrelated with the predictor or independent variables included in the model" (Torres-Reyna, 2007, p.25). Thus, the primary difference between the two models is the assumption by the random effects model that these variations across entities are random and do not correlate with the variables in the model. Random effect models use information from within and between individuals (Allison, 2006). According to Allison (2006), the difference between the two is that fixed effect models only use within individual differences and essentially ignore the differences between these individuals or entities.

Deciding between the fixed and random effect models is integral to using panel data. According to Clark and Linzer (2015), as a rule of thumb, when the number of total observations is smaller than 200, the random effects estimator outperforms the fixed effects estimator. This rule of thumb is the same even in extreme violations of the zero-correlation assumption. "The presence of non-zero correlation between the independent variable and unit effects is neither a sufficient nor a necessary condition for choosing a fixed effects model" (Clark and Linzer, 2015, p.406). The Hausman test can help decide between the fixed and random effects models (Torres-Reyna, 2007). Table C1 in Appendix C shows the results of the Durbin-Wu-Hausman test. The result indicates that the fixed effects model is appropriate for my regression.

5. Results

Table 2 presents the results of my analysis. Subsequent subsections detail the Modified Wald test for Groupwise heteroskedasticity and the Wooldridge test for autocorrelation. Both tests are shown in Tables 3 and Tables 4, respectively. Finally, due to the results obtained for the Modified Wald test and Wooldridge test, robust standard errors are estimated and presented in Table 5.

5.1 Fixed Effect Regression Results

The estimates obtained for all parameters are statistically significant. As economic theory predicts, the sign for life expectancy is positive. It indicates that as life expectancy increases, PAYG pension expenditure also increases. As expected, the fertility rate negatively correlates with PAYG pension expenditure. A decrease in the fertility rate increases PAYG pension expenditure. The employment-to-population ratio has a negative sign, as expected. An increase in the working-age population to the total population of these 20 OECD countries reduces their PAYG pension expenditure.

Table 2. Fixed Effects (within) Regression Estimation Results

Independent Variables	Co-efficient	Standard Error	t-statistic
fertr	– 0.529***	0.073	– 7.23
lifexp	0.073***	0.004	17.78
empr	– 0.043***	0.004	– 11.42
_cons	– 0.615*	0.371	– 1.66

**** p<0.01, ** p<0.05, * p<0.1*

Note: ln payg as Dependent Variable

5.2 Test for Heteroskedasticity

The Modified Wald test for GroupWise heteroskedasticity checks for the presence of heteroskedasticity in the data used.

Table 3. Modified Wald Test for GroupWise Heteroskedasticity

H0: sigma(i)^2 = sigma^2 for all i

	Coef.
Chi2(20)	10798.70
Prob>chi2	0.0000

With a statistically significant p-value shown in Table 3, it indicates that there is the presence of heteroskedasticity. The estimation results shown in Table 2, thus, cannot be interpreted with confidence due to the presence of heteroskedasticity.

5.3 Test for Autocorrelation

The Wooldridge test for autocorrelation in panel data checks for the presence of autocorrelation in the data used. "Serial correlation causes the standard errors of the coefficients to be smaller than they actually are and higher R-Squared" (Torres-Reyna, 2007, p.36).

Table 4. Wooldridge test for autocorrelation in panel data

H0: no first-order autocorrelation

	Coef.
F (1, 19)	1691.243
Prob > F	0.0000

With a statistically significant p-value shown in Table 4, I reject the null hypothesis of no first-order autocorrelation. Hence, the result indicates that autocorrelation is an issue within the data.

5.4 Robust Standard Errors Fixed Effect Regression Results

Robust standard errors for the fixed effects model deal with the issues of heteroskedasticity and autocorrelation. "The general robust standard error estimator, known in other models as the "cluster" estimator (introduced to FE by Arellano, 1987), is not only consistent in general but it behaves well in finite samples" (Kezdi, 2003, p.2). Thus, the advantage of the robust estimator increases as the time series gets longer (Kezdi, 2003).

For these 20 OECD countries in the 27 years, the signs of the coefficients obtained from my analysis are generally the expected signs. My research paper investigates how these demographic changes affect the PAYG pension system. Increasing life expectancy and declining fertility rate increases PAYG pension expenditure, which threatens its sustainability. Fewer contributions to finance the payment of pension benefits for a growing population of pensioners put the state in debt and make the PAYG pension system unsustainable. The effects are adverse regarding increasing the PAYG pension expenditure. However, the employment-to-population ratio does give evidence that reforms that can help improve the population of employers to the population of pensioners will decrease the PAYG pension expenditure and make it sustainable moving forward.

Table 5. Fixed Effects (within) Regression with Robust Standard Errors Results

Independent Variables	Co-efficient	Standard Error	t-statistic
fertr	– 0.529	0.374	– 1.42
lifexp	0.073***	0.018	4.14
empr	– 0.043***	0.013	– 3.27
_cons	– 0.615	0.773	– 0.79

**** p<0.01, ** p<0.05, * p<0.1*

Note: ln payg as Dependent Variable

A within R-Squared of 0.5847 indicates that the independent variables explain approximately 58% of the variations in PAYG pension expenditure. The robust standard error fixed effects regression results gave estimated coefficients of – 0.529 for fertility rate, 0.073 for life expectancy, and – 0.043 for employment-to-population ratio. The result shows that a decrease of 1 in total births per woman, on average and all else equal, results in an approximately 41% increase in PAYG pension expenditure. For the variable employment-to-population ratio, the result shows that on average and all else equal, a one percentage point decrease leads to an approximately 4% increase in PAYG pension expenditure. Since the number of children born reduces, the population of employed to the population of pensioners in the future decreases. However, the p-value for the estimated coefficient of fertility rate shows that this result is not statistically significant. The result not being statistically significant suggests that the data for fertility rate does not have significant variations within these twenty selected OECD countries over the 1991 to 2017 period. My result also shows that a 1-year increase in life expectancy, on average and all else equal, results in an approximately 8% increase in PAYG pension expenditure. An increase in life expectancy means individuals live longer, increasing the population of pensioners to receive pension benefits. Thus, pension benefits paid increase, directly increasing PAYG pension expenditure with fewer contributions from the working-age population to finance these payments.

6. Discussion

The outcome of my research has provided empirical evidence for the effect of demographic changes on PAYG pension systems. Estimated coefficients for life expectancy and employment-to-population ratio are statistically significant and generally have the expected signs. However, the estimated coefficient for fertility rate was not statistically significant even though it had the expected sign. This result means insufficient evidence to conclude that the fertility rate affects PAYG pension systems. Considering that the econometric model I used is a fixed effect (within) regression, the result for fertility rate shows low variations within the data used for this variable.

Both results obtained for life expectancy and employment-to-population ratio are in line with results from previous studies such as Alili et al. (2018), Casamatta and Gondim (2011), Kit (2015), Tabata (2015), and Yasuoka (2018). However, my result for fertility rate is not in line with the results from these previous studies. Chen (2015) and Kruse and Nyberg (2004), with the OLG model, also mention that the fertility rate significantly affects PAYG pension systems. The OLG model, used by these previous studies, uses a theoretical approach, whereas my approach uses empirical evidence. Thus, the difference in the method used can explain the difference in results obtained for the fertility rate. However, the development of Fanti and Gori (2012) aligns with my result that the fertility rate has no significant effect on PAYG pension systems in the long run. Fanti and Gori (2012) developed a diamond overlapping generations model characterized by a closed economy with identical two-period lived individuals and an exogenous number of children. This expanded model enabled them to conclude that the fertility rate has no significant effect on PAYG pension systems. My result suggests that future OECD pension reforms within these 20 countries do not need to focus on dealing with fertility rate, as one of the demographic changes affecting the sustainability of their PAYG pension system.

As mentioned previously, as far as I can find, no previous studies use econometric techniques with panel data for OECD countries to estimate the effects of demographic changes on PAYG pension systems. Thus, I have no previous studies to compare my estimated coefficient results directly. However, I can conclude that since my paper makes use of country and time-specific data, its conclusions and resulting policy implications are data-driven. My paper's results might differ from previous studies' results due to several factors. Any prior research has not used the econometric technique used by my paper, and my report covers a significant number of countries (20 countries) within the OECD. Furthermore, no previous study used the timeframe of the data for my study.

Based on my results, future pension reforms by OECD policymakers should focus on solving the negative effect of increasing life expectancy on their PAYG pension system. Pension reforms, such as increasing the retirement age, are designed to improve the employment-to-population balance and mitigate the effects of rising life expectancy on the country's population. According to Borsch-Supan et al. (2016), this increase in retirement age increases the number of active workers and decreases the number of active pensioners receiving PAYG pension benefits. I can conclude that demographic changes significantly adversely affect the PAYG pension system. That is, increasing life expectancy coupled with decreasing employment-to-population ratio. Conversely, falling fertility rates do not have a statistically significant effect on PAYG pension systems.

7. Conclusions

In this study, I estimate the effect of demographic changes on the PAYG pension system in 20 OECD countries using panel data covering 1991 to 2017. I use the fixed effects econometric technique to obtain estimates of the effects of life expectancy, fertility rate, and employment-to-population ratio on PAYG pension expenditure within the 20 selected OECD countries. The estimated coefficients show the impact of these demographic changes on the PAYG pension system. This study aims to provide empirical evidence to OECD policymakers on the specific demographic changes that need urgent attention regarding their effects on OECD pay-as-you-go pensions.

My findings indicate that life expectancy and employment-to-population ratio statistically affect the PAYG pension system. However, my result for fertility rate shows that it has no statistically significant effect on PAYG pensions. Therefore, declining fertility rates will have no significant adverse impact on PAYG pensions. Projected future trends of life expectancy and employment-to-population ratio show them to keep increasing and decreasing, respectively. Thus, mitigating their effects on PAYG pension expenditure should be at the forefront of significant pension policy reforms within the OECD. OECD policymakers should consider increasing the retirement age and improving the income structure of the economically active population to limit the impact of these demographic changes on the sustainability of the PAYG pension system.

A limitation of this study is that data for public pension expenditure was restricted to the period between 1991 and 2017 due to incomplete data covering other periods. Much of the data on public pension expenditure was incomplete, and thus, I had to exclude several other OECD countries from the data. Therefore, further analysis covering more extended periods with more OECD countries will be valuable in improving knowledge related to this topic. It will be interesting to see if the statistical significance of the fertility rate will improve by increasing the timeframe and number of OECD countries.

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Appendix A. List of Countries

Austria
Belgium
Canada
Czech Republic
Denmark
Finland
France
Germany
Greece
Italy
Korea
Luxembourg
Netherlands
New Zealand
Norway
Poland
Portugal
Spain
Switzerland
Turkey

Appendix B. Data Sources

PAYG	OECD – Pension Spending (Indicator)
FERTR	The World Bank (Database: World Development Indicators)
LIFEXP	The World Bank (Database: World Development Indicators)
EMPR	The World Bank (Database: World Development Indicators)

Appendix C. Durbin-Wu-Hausman (DWH) Test

Table C1. Hausman's (1978) specification test

	Coef.
Chi-square test value	55.254
P-value	0.0000