POPULATION AGING AND PUBLIC ECONOMY IN OECD COUNTRIES

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ABSTRACT

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This thesis considers effects of population aging on pension expenditures and public debt. Large generations are retiring while fertility rate has remained at low level and life expectancy is rising, which will concern the sustainability of public finances. Earlier empirical research has been argued that public pension systems might need reforms in order to finance the pension expenditures sustainably in the future.

In empirical research I consider the effects of the population aging on the government pension expenditures and the public debt in 22 OECD countries from 1985 to 2018. The empirical methodology used in this thesis is the general methods of moments (GMM).

Results show that the old age dependency ratio has a positive and statistically significant effect on the public debt. When Japan is excluded from the data, results are no longer statistically significant. Japan seems to be exceptional country due to its high old age dependency ratio and high debt level. In the case of pension expenditures, it seems that in other OECD countries than Japan the effect of older age structure is positive and significant on the pension expenditures. Unemployment also has a positive and statistically significant effect on the pension expenditures.

The population aging seems to have some effects on the pension expenditures in developed countries. Thesis emphasizes that reforms of the public pension system should be considered for every country individually.

Key words Population aging, public debt, public pension system, pension expenditures.
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TIIVISTELMÄ

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Tässä tutkielmassa tarkastellaan, millaisia vaikutuksia väestön ikääntymisellä on valtion eläkemenoihin ja velkaantumiseen. Julkisen eläkejärjestelmän rahoittaminen on herättänyt huolta useassa teollisuusmaissa, kun suuret ikäluokat ovat alkaneet siirtyä eläkkeelle. Samaan aikaan syntyvyys on pysynyt matalalla tasolla, kun taas elinajanodote jatkaa nousuaan. Aiemmassa kirjallisuudessa on perusteltu tarvetta julkisen eläkejärjestelmän uudistuksille, jotta eläkejärjestelmän rahoitus olisi kestävällä pohjalla väestön ikääntyessä.

Tutkielman empiirisessä osassa tarkastellaan, kuinka työikäiseen väestöön verrattuna yli 64-vuotiaiden osuuden muutos on vaikuttanut julkisiin eläkemenoihin ja valtion velkaan 22 OECD maassa vuosina 1985-2018. Koska työmarkkinoilla on ollut merkittävä vaikutus eläkejärjestelmien rakenteeseen ja uudistustarpeisiin, tutkimuksessa tarkastellaan myös työttömyyden suoraa yhteyttä valtion talouteen.

Tulosten perusteella ikääntyvällä väestöllä on vaikutusta valtion velkaantumiseen. Eläkemenoissa positiivinen vaikutus ei ole tilastollisesti merkittävä kyseisellä aikaperiodilla. 22 OECD maan aineistoon kuuluva Japani on poikkeuksellinen maa, koska maassa yli 64-vuotiaiden suhteellinen osuus työikäisiin verrattuna on suuri ja valtion velka on korkealla tasolla suhteessa muihin teollisuusmaihin. Maan poistaminen aineistosta heikentää ikääntyvän väestön vaikutusta valtion velkaan eikä vaikutus ole tilastollisesti merkitsevä jäljelle jääville teollisuusmaille. Lisäksi muiden maiden kuin Japanin osalta ikääntyneellä väestöllä näyttää olevan positiivinen vaikutus eläkemenoihin. Työttömyys vaikuttaa myös positiivisesti ja tilastollisesti merkittävästi eläkemenoihin näissä maissa.

Tutkielma osoittaa, että julkisen eläkejärjestelmän uudistamista tulee harkita maakohtaisesti. Osassa OECD maista väestön ikääntymisellä on yhteys eläkemenojen kasvuun. Kuten aiempi empiirinen tutkimus ja ennusteet demografisesta muutoksesta osoittavat, tällä hetkellä ikääntyvän väestön vaikutus julkisen talouden kestävyyteen ei ole niin merkittävä kuin se saattavat olla tulevaisuudessa.

Asiasanat
Ikääntyvä väestö, valtion velkaantuminen, julkinen eläkejärjestelmä, valtion eläkemenot.

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1 INTRODUCTION

After World War II birth rates rose in many developed countries. These few years created "baby boom" generation until the fertility rates started to turn down. Most of these countries have not reached such a high level of fertility again as in post-war period. Today, while the fertility rate seems to stay at a low level, this baby boom generation has started to retire. Some countries may benefit from a smaller share of younger generations when expenditure on age-related services of young people, such as education, is lower. Especially this would be benefical if the large generations of these populations do not entirely exit from the labor force.

Governments' old age-related expenditure will rise some day when the whole baby boom generation retires. The retirement of the large generations is one reason to discuss a sustainability of the public pension system, but it is not the only reason for the higher expenditure. Life-expectancy has increased substantially after many breakthroughs in the past, such as medical improvements and the industrial revolution, which has expanded economic growth and therefore, well-being. The life expectancy is projected to continue the rise in the future.

Governments' ability to cover an increasing age-related expenditure may evoke to reconsider the fiscal policies. Decreasing working age population and large generations exiting from the labor markets will reduce the government's tax revenues. One may suggest that higher tax rate and collected pension contributions would solve the problem by increasing revenue. At the same time, it will be disadvantage to the working age population, which are the payers of the current pension payments. Changes in the age structure and impacts of the demographic change on the public economy have discussed in Chapter 2.

Since the fiscal policy has its own downsides, the projected demographic change in industrialized countries has evoked the need to reform the public pension system. The pension system was established to provide people whose capability for work has weakened with income. Nowadays, the pension system works as a saving system for the future spending and will make early retirement possible. At the same time increasing life expectancy means that retirees can enjoy longer time on retirement. When the main purpose of the public pension system has been to prevent poverty amongst elderly population the increasing expenditure due to the population aging is a real challenge to overcome. The pension systems of OECD countries will be discussed in Chapter 4.

This study considers a state of the public economy in some developed countries. Chapter 3 covers a structure of the public economies in OECD countries and gives some motivations to study a sustainability of the public pension system. Since the demographic change has been projected to disturb the governments' fiscal balance, it will arise a concern of mounting public debt. After the 2007-2008 financial crises the debt levels rose in Europe and they have not recovered as much as they should have. The aim of this empirical research is to

find the link between a demographic change and the public economy in developed countries if there is any. Some researchers have argued that there will be some consequences of demographic change in the future. Earlier empirical research discussed in Chapter 5 is followed by the empirical research of the population aging and the government expenditure and the public debt.

2 POPULATION AGING

2.1 Fertility and life expectancy

Life expectancy has risen in OECD countries and it has been projected to continue its increasing path. Figure 1 illustrates a trend of the life expectancy in Europe and Northern America. The figure shows that the life expectancy is higher in Europe and Northern America than in the world on average.

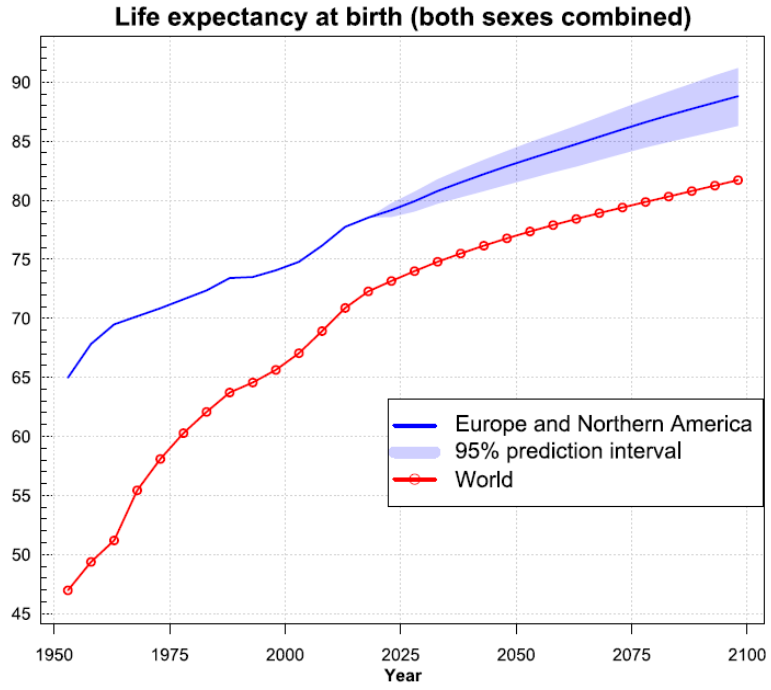

Figure 1. The life expectancy

Source: United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects 2019, Volume II: Demographic Profiles

The fertility rate has been at high level after second world war in many advanced countries. It has started to decrease at the end of the 1900-century. Figure 2 illustrates a decline of the fertility rate in Europe and Northern America after 1950. The substantial change can be seen worldwide. As the figures show the fertility rate has fluctuated more than the life expectancy which has increased steadily for many decades.

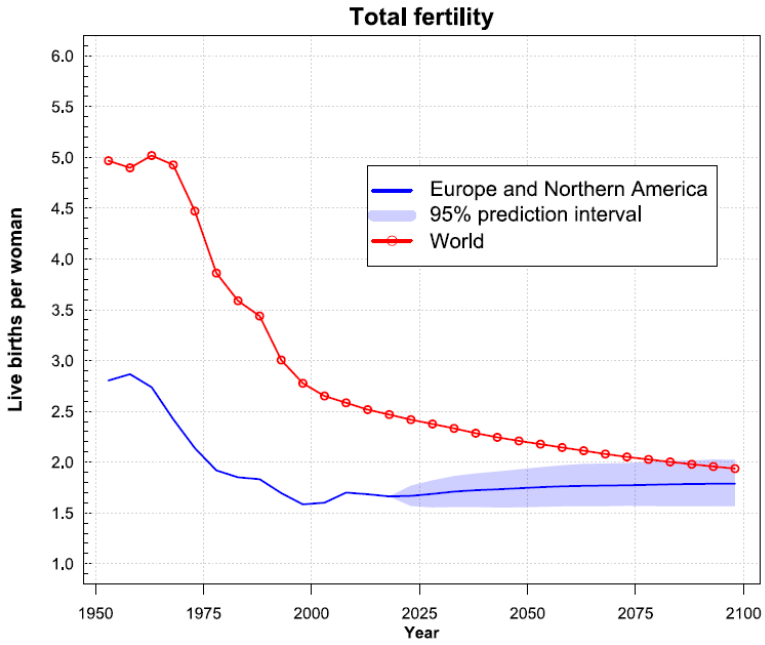

Figure 2. Total fertility rate, Europe, and Northern America

Source: United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects 2019, Volume II: Demographic Profiles

The fluctuations of the fertility rate appear on a country level. The figure 3 shows that in Sweden fertility has been high in 50′ and 60′ and peaked again at early 90′. At the end of the 70′ and 90′ the fertility rate has declined substantially. Northern Europe has faced similar changes. There is uncertainty how the fertility rate will change in the future. In the figure 3 a large margin of error indicates that the fertility rate is difficult to forecast.

Life expectancy is more predictable than fertility. In the long run the fertility rate seems to have a declining trend in advanced countries whereas it is almost impossible to forecast in the short term. Timing and changes of the fertility vary between countries. Based on data from the World Bank database from 1985 to 2017 the fertility rate has remained nearly at the same level in the Great Britain. In some countries, such as Denmark and Germany, the fertility rate has shown a little growth. Goldstein and Kluge (2016) argue that many Eastern European countries have favorable demography today and the fertility rate will lower later. Demographic change in the future occures differently also in developing and developed countries.

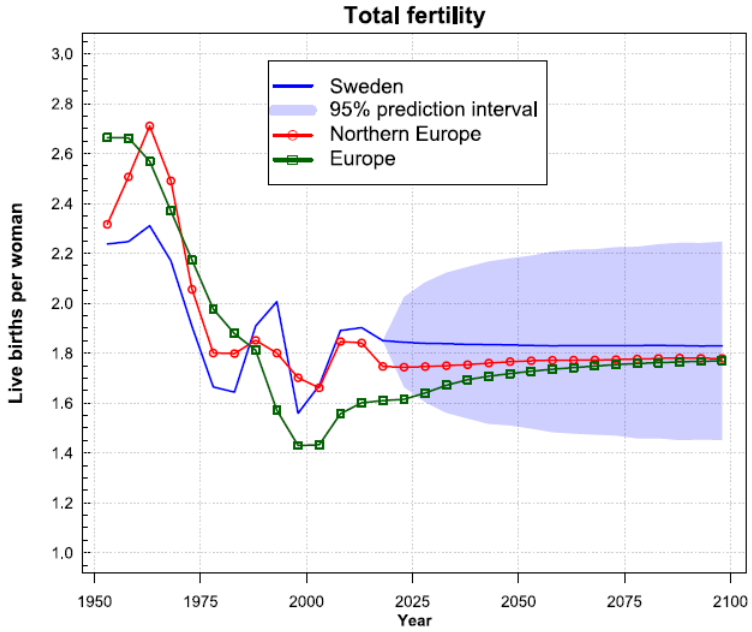

Figure 3. Total fertility rate, Sweden, and Europe

Source: United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects 2019, Volume II: Demographic Profiles

Figure 2 shows that globally a decrease in the fertility rate has been quite steady and the global fertility has forecasted to stay at low level. In a single country and in smaller regions one can see fluctuations as figure 3 shows. Prediction interval of the fertility rate is broad, which means that there will be much uncertainty on projection at country level. The fertility rate can be highly sensitive in the long run projection.

Fertility and life expectancy have different effects on the population aging depending on the current age structure. Despite contrary findings of the effects, both the fertility and the life expectancy together have substantial impacts on the age structure. For example, Kudrna et al. (2015) find out that projected increase in longevity is the main driving force for the population aging in Australia. The impacts of the fertility were relatively small. Contrary to that, Attanasio et al. (2007) find out that increase in longevity does not play as important role as fertility.

2.2 Age structure

Dependency ratios can compare the youngest or oldest population to a working age population. The old-age dependency ratio (OADR) shows how many individuals at the age of 65 and over there are per 100 individuals at age of 15 to 64, which is defined to be the working age population. For example, Japan's OADR is 46 in 2018, which means that Japan has 46 over 64 years old individuals

per 100 working age invidivuals. Japan's population's age structure is old compared to many other advanced economies.

Different age groups of European population have been compared in the figure 4. A share of over 64 years old has increased since 1950. The size of this age group will continue to grow for few decades. The forecast shows the increasing trend slows down after 2050. A share of population at the ages of 25 to 64 years old is a crucial part of the working age population. The figure 4 shows that this age group has increased since 1950. Currently the trend seems to turn down. The age group of 25 to 64 has projected to decrease until 2100. The figure 4 shows how the age stucture of Europe is projected to change. The share of over 64 years old is closing the gap on the share of 25 to 64 years old.

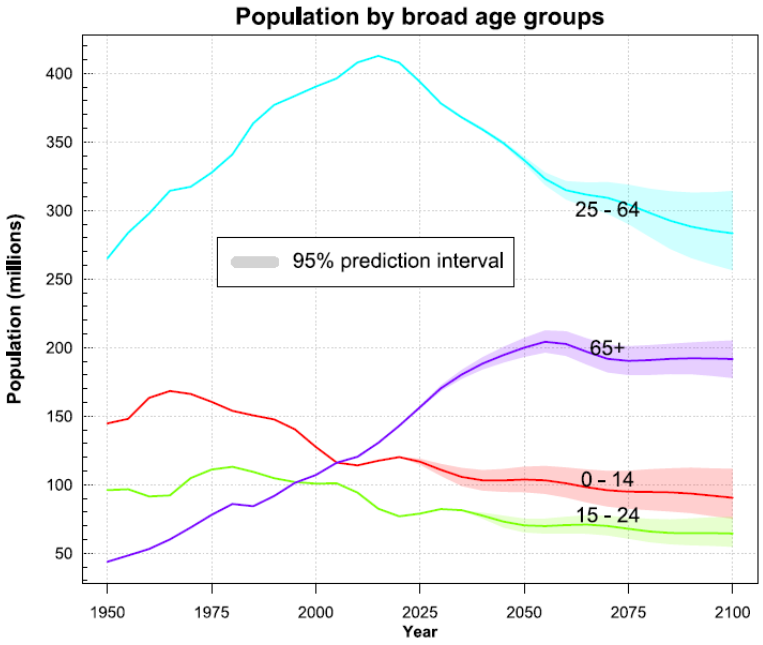

Figure 4. Population by age groups, Europe

Source: United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects 2019, Volume II: Demographic Profiles

More dramatic changes can be seen in the figure 5. The decline in the Japanese population at the working age of 25 to 64 years old has started earlier than in Europe. The gap between age groups of over 64 and 25 to 64 is also projected to decrease more than in Europe. Japan has faced the significant change of the age structure around in 2000.

Figure 6 illustrates how the population in Canada differs from the age structure of Japan and Europe. All age groups are growing. In contrast to Japan and Europe the population of 25 to 64 years old is projected to continue growing. Same trend has been forecasted also for the population of the United States. (United Nations, 2019)

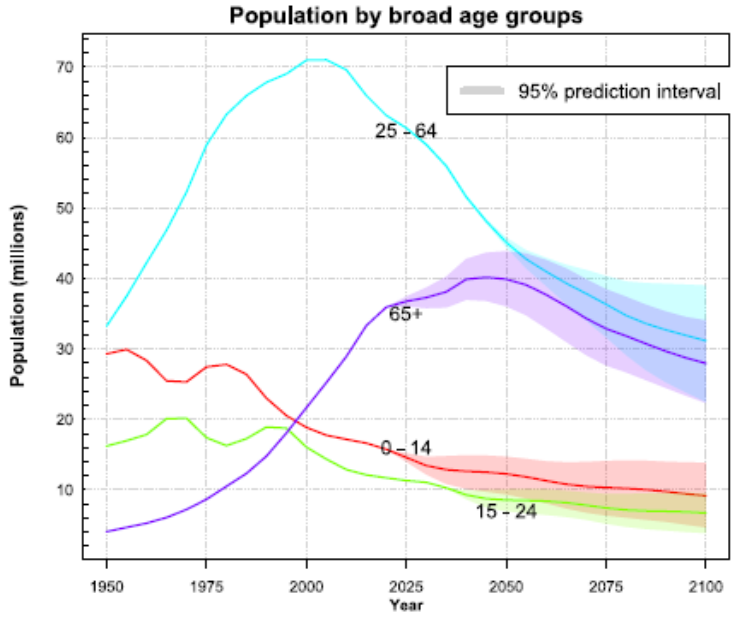

Figure 5. Population by age groups, Japan

Source: United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects 2019, Volume II: Demographic Profiles

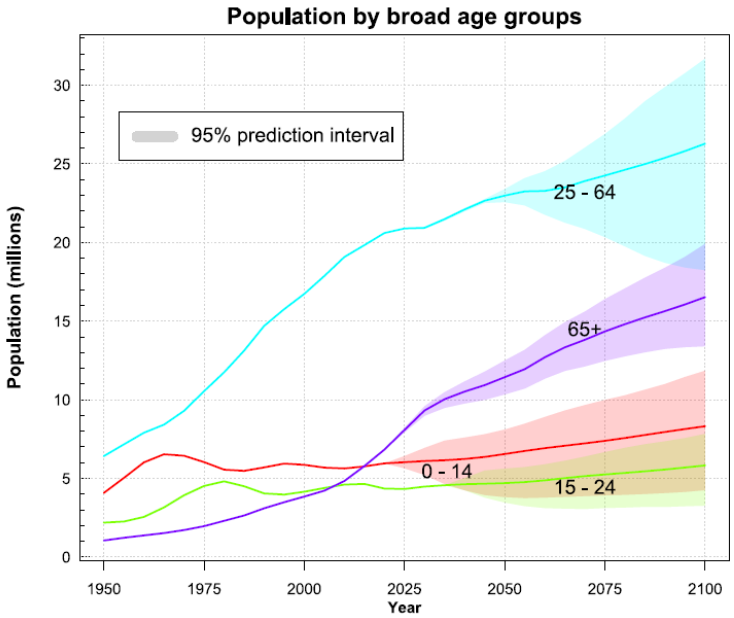

Figure 6. Population by age groups, Canada

Source: United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects 2019, Volume II: Demographic Profiles

Lower fertility has affected the size of the working age population in many advanced economies. At the same time, people live longer than before, which affects a size of over 64 population. Therefre, the old-age dependency ratio explaines the changes of the age structure better than a fertility rate or a life expectancy separately.

OADR is commonly used to describe the changes in the age structure. The ratio compares a share of the working age population, which is affected by changes in fertility and a share of over 64 years old, which will grow due to increasing life expectancy. The old-age dependency ratio has rosen in most OECD countries. Many studies have projected that it will continue this trend. For example, Rouzet et all., (2019) project that the number of people over 64 for each working-age person will double by 2060. However, based on data from the World Bank's database in Canada, for example, the old-age dependency ratio has not change as much as in many other advanced countries. The figures above show that in the advanced economies the population of over 64 years old has projected to increase and the working age population will shrink except in Canada, where all the age groups have been projected to grow.

Since many nations have noticed that the demographic change has fiscal impacts in the long run, some of them have made or at least considered long-lasting reforms to control the age-related expenditure. Next sections will discuss the impacts on government's fiscal performance and the sustainability of pension systems as a part of the government's expenditure.

2.3 Population aging and age-related expenditure

Increasing life expectancy is affecting funding requirements of a pension system and a health care by raising payments and expenditure. Piggott and Woodland (2016) state that expenditure to finance the health programs which are provided by government are strongly correlated with age. In the case of the pension programs growing number of retirees requires more funding for raised benefit payments. The public pension expenditure is already significant whereas increases in expenditure to finance the health care and the long-term care programs are projected to be larger in the OECD countries. (Piggott and Woodland, 2016).

Piggott and Woodland (2016) project changes in three age-related government expenditure; long-term care, health care, and pensions of few OECD countries[1] from 2006 to 2060. The long-term care expenditure is projected to double over this period and the health care expenditure will rise from around 6 % to around 12 % of GDP. (Piggott and Woodland, 2016).

The fiscal impacts of increasing life expectancy depend on the quality of the added years of people's life. A healthy lifestyle may help people to keep the

[1] Australia, Belgium, Germany, Italy, the UK, and the USA.

doctor from earnings his bread and better health care helps to recover from deseases. Piggott and Woodland (2016) mention that one reason to higher government expenditure to fund the health care program is the technical improvements in health care which extend a range of the health services.

Pension expenditure is affected by a higher life expectancy and the larger number of retirees and changes in pension expenditure vary between OECD countries. Piggott and Woodland (2016) find that changes of the pension expenditure are modest though the pensions are already at a high level in few OECD countries. In the case of Italy, the pension expenditure is projected to decrease from 2006 to 2060 (Piggott and Woodland, 2016). Although the increases in pension expenditure will be few persentages in some OECD countries, the pensions are already a significant portion of expenditure. For example, in Germany pensions will increase from 10 % to 12 % of GDP until 2060 (Piggott and Woodland, 2016).

Lower retirement age and higher life expectancy has increased duration of retirement. Schwarz et al. (2014) find the largest increase in Belgium where expected years in retirement have changed from 15 years to 25 years from 1970 to 2009. In Spain, the effective retirement age was 71 in 1970 and it lowered to 63 by 2009 (Schwarz et al., 2014). In 2018 the effective retirement age was even lower than ten years ago at the age of 62 (OECD, 2019(b)).

Demographic change affects expenditure differently depending on the government's policy to provide social security. Jung and Tran (2017) argue that in the USA the population aging impacts on health spending by the government may be even more important aspect than impacts on social security payments. In Europe, the public pension system is a significant part of the European member state's old-age social security systems. The structure of government spending and public pension systems will be discussed more detailed on next chapters.

2.4 Population aging and fiscal balance

When the government's expenditure exceeds the revenue, it will lead to a fiscal imbalance. Fehr et al. (2008) emphasize the increase in life expectancy of OECD countries that will cause a fiscal pressure, will be more significant in the future than it has been. As the working age population has been projected to shrink in the future, the work income to tax will be less without taxation reform. Increases in fertility would relieve the pressure, which is contrary to many projections of lower fertility rates.

Piggott and Woodland (2016) project that the impacts of population aging on the fiscal balance will be severe by 2050. One way to maintain the fiscal balance is to finance the exceeded expenditure by a public debt. However, this would be another challenge to overcome since the financial crisis in 2008 has left high debt levels in many countries. Impacts of population aging on a public debt may not be a large yet. Afflatet (2018) finds out only a weak evidence to support

the effects of the population aging on the public debt in 18 European countries until 2015. As the author mentions that these empirical results do not rule out concerns of the impacts on public debt in the future.

Goldstein and Kluge (2016) emphasize the need for new policies based on their calculations of the changes in age structure and European government budget deficits, which they called a demographic deficit. Forecasting might be impossible, but their estimations from 2010 to 2060 are providing one scenario. Goldstein and Kluge (2016) find out that especially countries with favorable demography today will experience sharp raise on the demographic deficit in the future.

3 GOVERNMENT BUDGET

3.1 Expenditure on public economy

Government provides with public goods and services and transfers income through social security system, which includes pensions, family benefits, and unemployment benefits. (Wickens, 2012) Structure of the government's expenditure depends on priorities and challenges, such as poverty prevention or demographic change.

Government's expenditure in OECD countries was 40,4 % in relation to GDP in 2007. Over ten years period the expenditure has not changed. The largest expenditure over 50 % in relation to GDP was in France. In Finland expenditure has risen over 50 % in relation to GDP by 2017. (OECD, 2019(a)). Expansionary countercyclical fiscal policies may lead to higher share of expenditure. From 2007 to 2017 the expenditures increased the most in Norway due to fiscal policies although the government's expenditure has not risen over 50 % in relation to GDP, such as in Finland. (OECD, 2019(a))

Social protection, which includes old age, disability and sickness pensions, housing and unemployment benefits, has been the largest source of government expenditure in OECD countries in 2017 (OECD, 2019(a)). In most Nordic countries and for example, in France, Belgium, Austria, Italy, Greece, and Germany the social protection is high priority while Korea, Chile, and the United States spent the least on social protection. (OECD, 2019(a))

In Norway, higher public spending on social protection is one reason for increased expenditures. From 2007 to 2017, these expenditures have increased over 3 % in relation to GDP. In Finland, as well as in France and Italy, the social protection expenditures have risen the most and were at high level compared to other OECD countries in 2017. The expenditures have not increased as much in Sweden, Denmark, and Austria, although in these countries a share of the social protection has been at high level. (OECD, 2019(a))

Over half of the funds for a social protection has been allocated to pensions. Old age pensions are 10 % in relation to GDP in OECD countries in 2017 and over 13 % in relation to GDP in Finland, Greece, France, and Italy. (OECD, 2019(a)) Old age pension has an important role to prevent poverty at an old age. Pension is primary income source for many older people.

Second largest source of government's expenditure has been health care. (OECD, 2019 (a)) The United States spends more on health care than social protection. In the United States, health care expenditures was the highest source of government's expenditure in 2017 whereas social protection expenditures were one of the lowest compared to other OECD countries. (OECD, 2019(a))

3.2 Public finance

Government's expenditure can be financed through government revenue, borrowing, and printing money. Latter way has been more common in the past, particularly in ex-Soviet Union states. The pure-money financing of fiscal expenditure has been seen as an efficient source to accelerate the inflation. These countries in the 1990s and Zimbabwe in 2007 had not an adequate tax base and they had to pay government's expenditure by printing money, which has caused hyperinflation. (Wickens, 2012)

Government revenue includes tax revenues, social security contributions, and non-tax revenues. Tax revenues consist of personal income and corporate income taxes and indirect taxes. Golden rule of public finance is that the current revenue should cover the current expenditure during an economic cycle. The public debt should be used only for investments that enchance the economic growth. (OECD, 2019(a))

The public debt consists of all liabilities, which includes also shares, equity, and financial derivates, which are not debt. (OECD, 2019(a)) The public borrowing means that government sells debt securities to investors. It gives those investors a right to payments in capital and interests of debt for a given period. (Wickens, 2012) In the OECD countries most of the government gross debt is held in debt securities.

3.3 Intertemporal budget constraint

Intertemporal budget constraint of government must be satisfied in order to maintain a fiscal balance. The budget constraint consists of government debt, spending, and taxes. With the price level p_t, the nominal budget constraint is in the form

$$p_t G_t - p_t T_t + r_{t-1}^n p_{t-1} B_{t-1} = p_t B_t - p_{t-1} B_{t-1}. \quad (1)$$

The budget constraint consists of two periods, the current timeperiod, *t*, and the previous timeperiod, *t-1.* Right-hand side of equation is the mounting debt at period *t* relative to the previous period. Left-hand side of equation describes expenditures at the period *t* that government should cover. Revenue, T_t, has been used to finance expenditure, G_t. The sum of the expenditure that exceeds the revenue is financed by the public debt, B_t. Term r_{t-1}^n denotes interest payments

of the public debt, which have accrued from the public debt during the previous period, B_{t-1}. The government budget constraint can be rearranged as follows:

$$g_t - \tau_t = b_t - \left(\frac{1+r_{t-1}}{1+z}\right) b_{t-1}. \quad (2)$$

The nominal variables are divided by nominal GDP in order to get the real values of fiscal variables. Real fiscal variables are noted with small letters. In equation (2) a deficit is financed by a public debt. The fiscal variables have been divided by a nominal gross domestic product and the equation describes a real budget constraint. Formation has defined more accurately on Appendix A.

Although government debt is not required to repay entirely, continously mounting debt level is a concern for investors, who will buy the debt securities. (Wickens, 2012) When the deficit mounts the public debt consecutively, which leads to higher interest payments, the government faces a pressure to reduce the fiscal deficit. The public finance must be sustainable in order for the private sector wants to hold the debt securities of the government.

In equation (2) the growth of real GDP is represented as $1 + z$. The debt accumulation is a worse problem for countries that have a slow economic growth. The mounting debt level means the higher interest payments. If the interest rate of the public debt is higher than the growth of GDP, the government should either borrow more to finance the interest payments and possible deficit or run the surplus which covers the interest payments. When the government's budget is balanced, in other word, the expenditure equals to the revenue, new debt must cover the interest payments of the previous public debt. In the long-run the surplus is the most sustainable strategy. In order to finance the public expenditures sustainably, running the deficit and financing the interest payments by the public debt may be the worst case. This option can be considered as a short-term strategy.

3.4 Fiscal balance

Fiscal sustainability of public finances means that government can finance the current public debt and expenditures with revenues in the long run. The fiscal balance means that revenue equals to expenditure. In the short run the government can borrow to finance the deficit when the expenditure exceeds the revenue. If the public debt to GDP ratio will rise continously, it may be a sign of unsustainable fiscal balance. Wickens (2012) notes that if the expenditure exceed revenue persistently and the private sector is unwilling to hold the government debt due to the mounting debt level, the remaining option to finance expenditure is printing money. As mentioned earlier this might lead to hyperinflation.

European Union has created rules and pacts for member states to achieve a sustainable fiscal stance. The Stability and Growth Pact (SGP) guides to handle excessive budget deficits or public debt and to prevent fiscal policies from heading to unsustainable direction. Government's fiscal stance can be defined by a medium-term budgetary objective (MTO), which includes three fundamentals. First fundamental advises to keep a net expenditure growth in line with a potential growth rate. When the member state is not at MTO, an instrument to close the gap with the MTO is to set the rate of net expenditure growth below the potential growth rate. Second fundamental urges to keep a percentage of government expenditure in relation to GDP constant. The insturment to meet the rule is simply to decrease the government's expenditure. Last fundamental is that the member states should remain at MTO. Otherwise, the government must strengthen a structural balance. (European Comission, 2019)

A deficit limit is one criterion to define MTO level for each country. Each member states have calculated the minimum value of the MTO for assessing the deficit limit. The minimum value takes into account an output volatility and a budgetary sensitivity to output fluctuations. (European Comission, 2019) More countries economy fluctuates, more strict the pact is for country.

Other criterion takes into account implicit liabilities and the public debt. The debt ratio should convergence to sustainable level. Minimum value for MTO takes into account the economic and budgetary impact of ageing population, such as projected increase in age-related expenditures. (European Comission, 2019)

Rearranging equation (2), next equation shows that the deficit is straight gain to the public debt.

$$b_t = d_t + \left(\frac{1+r}{1+z}\right) b_{t-1} \tag{3}$$

$$g_t - \tau_t = d_t > 0.$$

In equation (3) the government run a deficit, $d_t > 0$, due to higher expenditure than revenue. After the financial crisis, which starts in year 2007, many governments of OECD countries ran a large deficit. (OECD, 2019(a))

When the public authority follows a balanced budget policy, expenditure equals to revenue, $g_t - \tau_t = 0$. The debt to GDP ratio can be rewrited as follows:

$$b_t = \left(\frac{1+r}{1+z}\right) b_{t-1} \tag{4}$$

In equation (4) the real interest rate, r, is assumed to be constant in the steady state. When the growth of GDP is higher than the real interest rate of the public debt, $r < z$, the debt to GDP ratio will approach to zero. (Junttila, 2019)

The fiscal deficits have decreased slowly from the highest levels after the global financial crisis. In 2017 a little over one-third of OECD countries have run a fiscal surplus. For example, in Norway the surplus was 4,9 % in relation to GDP, which was the highest of OECD countries. (OECD, 2019(a))

4 PENSION SYSTEM

4.1 Structure of pension systems

When society moved from agriculture to industry and women's participation in labor markets became more common, a larger share of the population joined the work force. This development increased a demand for the pensions. Right back in the early days the pension system provided with income when person's capacity for work started to weaken. Nowadays, the idea of the pension system has moved from this limited "insurance" which secures an individual with incapacity for work at an old age to "saving" scheme for the future spending. (Schwarz, 2014)

The mandatory form of the pension system ensures that individuals save from the labor income in order to spend a part of the lifetime income later. Many current pension systems require a minimum path of contribution records or a certain time path as a resident of the country to get full pension benefit. In many countries the minimum path of the contribution records is 40 years, or 36 years as in Spain, or even as high as 45 years as in Belgium. (OECD, 2019(b))

The legal retirement age defines the eligiblility age for a pension benefit. The labor force participation after the actual retirement age has decreased during the development of the pension system. Firstly, the earlier retirement has became possible. Secondly, when people become wealthier, they have tendency to prefer leisure to work. Schwarz (2014) showed that in the twenthieth century the percentage of retirees below the normal retirement age increased from 5 percent to over 50 percent by 1976 in Austria and Germany and from 9 percent to 21 percent in Sweden by 1974. Labor force participation rate of worker who has crossed the actual retirement age fell from 16 percent to 8 percent by 1980 in Europe. (Schwarz, 2014)

The growth of the participation in the labor markets shifts the public pension system towards a pay-as-you-go (PAYG) scheme. (Schwarz, 2014) The scheme is sustainable when a working age population is large enough compared to retirees. In the PAYG pension system the sum of annual contributions collected from working population equals the sum of the pension payments in the same year. The working age population is financing the pensions on the PAYG system and therefore, the population aging is concerning the sustainability of the public PAYG pensions systems in the long run. This system has worked well when the working age population has been large enough to cover the pension payments.

When the working age population has started to shrink and the life expectancy has continued to increase, many countries has reformed the retirement age. In 2018 the normal retirement age, which is the age of eligibility to mandatory pension system, was 65 or 66 in many OECD countries. The average of normal retirement age in OECD countries was around 64. The average effective age of labor market exit, the age when people actually retire, was around

64 for women and around 65 for men. However, the normal retirement age has not been equal to the effective age of labor market exit in many OECD countries. For example, in Belgium and Italy the normal retirement age is 65 and 67 while the effective retirement age was much lower, around 60 in Belgium and under 65 in Italy. Contrary, in New Zealand and in Japan the effective retirement age is substantially higher than the normal retirement age. For example, men in New Zealand retired at age of 70 on average in 2018 while the age of eligibility was 65. In Japan the effective retirement age was 71 for men. (OECD, 2019(b))

In a universal pension system, all retirees receive the same flat rate payment after the certain age. Pension benefits can be also linked to earnings. (Piggott and Woodland, 2016) In earnings-related pension scheme a benefit calculation is based on the revalued earnings during a certain time path or the lifetime earnings. For instance, Australian earnings-related pension benefit for individual who was born before 1955 is measured by the best revalued earnings of 30 years and for those who was born in 1955 and after is measured by the lifetime earnings. (OECD, 2019(b)) Many OECD countries' pension system has both a universal and earnings-related pension scheme.

National pension systems are usually combinations of unfunded and funded, public and private elements. Pension payments can be financed by the state from public revenue or a PAYG basis, or the payments could be funded by the pension funds from individual's contributions and accumulated assets. The most common system to finance the public pensions is the PAYG basis. (OECD, 2019(b))

To give an example of a combination of the pension schemes Australian pension system has three schemes: a compulsory employer contribution to private fund, a means-tested Age Pension, and voluntary private contributions. The first scheme collects a mandatory contribution from the employee's earnings to private pension plan. The Age Pension is financed by general revenue, in other words by current income taxes. A retiree who has reached the certain age and who satisfies the means tests, both an income test and an assets test, is eligible for the Age Pension. (OECD, 2019 (b) and Piggott and Woodland, 2016) The pension system has its mandatory and voluntary schemes, a funded private pension and unfunded public schemes.

Lastly, the means testing has become more popular in advanced countries. Generally, means testing is used to determine an eligibility for the old age pension and a level of pension benefit which depends on retiree's ability to consume in retirement. Income test can be separate for two tests, for earnings from work and for investment income which is measured by interests and dividends. In the United Kingdom the age pension is tested by the earnings test. Canada's Old Age Security Pension depend on the income test. In the United States the pension payments are subject to earnings, income, and resources tests. (OECD, 2018)

In practise the means testing sets a specific threshold for assets or income. For example, in the Australia's Age Pension scheme a pensioner can get a full pension when the income and assets are below the threshold. A pension payment

reduces linearly with increases in income or assets when the threshold has been exceeded. (OECD, 2018 and Piggott and Woodland, 2016)

4.2 Features of pension system in OECD countries

The public pension system has many different features such as consumption-smoothing, relieving poverty, and redistributing income. Schemes may have different purposes, but one similarity is that the pension system should be financed sustainably. For example, the PAYG scheme and a system which based on means testing have a same redistributing feature, whereas these schemes are financed differently.

The mandatory public PAYG system allocates income from the working age population to retired people. When the population is aging, the PAYG scheme can be seen to pressure the fiscal sustainability. Means testing allocates income from wealthy people to poorer. Contrary to the PAYG system, the means testing releases the pressure of unsustainable government expenditure better when the population is aging. Incomes are allocated from whealthy people to retirees who are most in need. (Piggott and Woodland, 2016)

In addition to redistributing and financial sustainability features, the means testing scheme provides with a public insurance to secure against the income risk. Especially, it is crucial for those who do not get that security from the private sector. Means tested pension compensates the livelihood at retirement if individual has had a low wage period at the end of the working life. (Piggott and Woodland, 2016)

A mandatory pension system may be required to solve insufficient saving behaviour of people. People may not be forward-looking, and they prefer current consumption to saving for the future. Therefore, the mandatory scheme is needed for consumption smoothing.

Individual faces risks which can be related to the pension system. As mentioned above, people face income risk, which can be solved with the public insurance. A social risk arises when an individual is financially disadvantaged due to a high retirement age. These individuals have for example a lower life expectancy than on average and, therefore, they receive a lower return on contributions they have made under the funded pension system. (OECD, 2018)

While many countries have raised the normal retirement age due to the population aging, some people have been penalised due to their shorter life expectancy. For example, in Canada the retirement age has been kept flexible. When individual retires after the normal retirement age at 65, the pension payments will increase up until the age of 70. It is also possible to retire at age of 60 with reduced pension payment. (OECD, 2018)

Demographic change has challenged especially the financial sustainability of the PAYG pension system. While the working age population is shrinking and the large generations are retiring, the increasing life expectancy leads to the retired people staying longer in retirement. A life expectancy at age 65 is around

20 years in many OECD countries and exceptionally in Japan the life expectancy at age 65 was 22 years, which means that Japanese retiree will spend 22 years at retirement (OECD, 2019(b)).

Reforms to ensure the financial sustainability of the pension system are, for example, increase the retirement age, cut the pension benefits, collect more taxes or contributions. Many OECD countries have raised the age in which individual is eligible for full pension benefit. For example, in Austria the normal retirement age for women will increase from 60 to 65 by 2033 and it will catch up then the current retirement age for men. In the United State the current retirement age, 66, will increase to 67 by 2022. (OECD, 2019(b)).

4.3 Adequacy and poverty prevention

Many reforms that ensures the fiscal sustainability have effects on the adequacy of the pension system. More strict rules for eligibility affect a coverage and this might cause poverty among the elderly people. (OECD, 2018) A challenge of the pension reform is how to fulfil both the fiscal sustainability and an adequacy of provided income on retirement.

Lower pension benefit reduces the government expenditure, and it helps to reach the fiscal sustainability. At the same time, a lower benefit challenges a livelihood of the pensioners who have lean on the public pension system. Some OECD countries have introduced the supplementary pension to provide individual who has a low pension benefit with more adequacy pension while the pension system reduces the pressure on the public finance. (OECD, 2018).

Japan is an extreme case of the advanced economies in terms of the population aging and poverty of elderly people. Japanese population is older than in the OECD on average. The public pension spending was 10,2 % of GDP in 2018. That is at the same level as in Germany where the old age dependency ratio is substantially lower. (OECD, 2019 (b)) While the population in Japan has aged more than in other OECD countries, the governments pension spending has not risen as much. In Japan the relative poverty rate of people at age over 65 is 19,6 % while in the OECD countries the poverty rate is 13,5 % on average. (OECD, 2019 (b))

Poverty prevention has been more serious agenda in OECD countries, such as Canada, Denmark, New Zealand, and Norway. In these countries a poverty reliefing old-age safety-net benefit is over 30 % of the gross wage. In Japan the same safety-net benefit is 18,4 % of the gross wage. (OECD, 2019 (b))

4.4 Pension system and labor markets

Labor markets and the pension system has a strong connection. When the labor force has faced some changes, it has caused a need for a reform of the pension.

Börsch-Supan et al. (2014) emphasize that a combination of pension and labor markets policies can do more than such policies in isolation due to this interact with each other. In the United States the retirement benefit increases if retiree work after the normal retirement age of 66 up to the age of 70. (OECD, 2019 (b)) This may encourage to work after the normal retirement age if it is possible. Increased retirement benefit is beneficial if the current pension benefit is not covering the planned consumption in the retirement.

The average effective age to exit the labor market was 71 for Japanese men and 69 for Japanese women while in OECD countries workers exit the labor market at the age of 64, approximately. In Japan 47 % of the people at the age of 65 to 69 were employed in 2018. The employment rate of older workers is higher in Japan than in the OECD countries on average. (OECD, 2019 (b)) Japanese workers stay longer in the labor force, althought the eligibility for pension benefits has reached at age 65 as in many other OECD countries. Work older may be only way to prevent the poverty at older ages.

5 LITERATURE REVIEW

The population aging and its fiscal impacts have been studied broadly. For example, Piggott and Woodland (2016) argue that the old-age related expenditure has been projected to rise in the United States, Japan, and Australia. Authors emphasize the need for a rise of the tax rate to finance the government's real expenditure in order to maintain a balanced budget. Most implications of the national and international studies are line in with the study of Piggott and Woodland (2016).

Japan has faced fast aging of the population. In the 1990 the country had young population compared to other developed countries. Nowadays, Japan has one of the oldest populations. At the same time the high debt-GDP ratio is another challenge to overcome. National studies by Braun and Joines (2015) and Kitao (2015) support the argument that the demographic change will lead to the budget imbalance in Japan.

In theory, the larger share of elderly people leads to the higher expenditure as discussed in Chapter 2. Guest and Mcdonald (2000) prove empirically that expenditure to finance the social security system will grow significantly in Australia from 2011 to 2031, when the large cohort of older people retires. More recently Kurdna et al. (2015) find also that the population aging has fiscal effects on old age-related expenditure in Australia. Kitao (2015) supports these findings by arguing that the large cohort of retired people, longevity and lowered fertility have effects on the pension and health care expenditure in Japan. Zokalj (2016) finds a small growth in the pension expenditure in European countries.

Recent studies have found that the population aging affects budget balance negatively. Kitao (2015) find that demographic change will lead to budget imbalance in Japan. Both studies of Yoon et al. (2014) and Zokalj (2016) find that the larger positive effect of the population aging on expenditure than revenue affect the budget balance negatively in OECD countries and Europe. Theoretically, the older age structure increases a deficit due to the slower increasing revenue than the expenditure. From 1975 to 1992 there is empirical findings of the effects on the budget deficit only for developing countries, according to Chen (2004). On the period of 1995-2014 Zokalj (2016) finds the positive effect on the budget deficit in European countries. It seems that more recent studies have found some connection between the population aging and the government budget.

As in theory, the higher budget deficit leads to the higher public debt levels, ceteris paribus. Other studies find that the population aging has an effect on the budget deficit, the similar effects should be found on the public debt. Afflatet (2018) finds only a small empirical support that the population aging affects the public debt before the year 2015 in European countries. Study emphasizes that the effect of population aging on the public debt has not appeared yet. Author mentions that until now the population aging has been managed without the mounting public debt.

Empirical research finds links between the population aging and the government budget, as well as, the labor markets. Both national and international studies show similar results that the population aging will stress the government budget and requires fiscal policy reforms. Age structures of countries differs and will evolve differently over time. Piggott and Woodland (2016) emphasize the importance of multicountry samples to make more general implications than a research of a single country.

6 DATA AND METHODOLOGY

6.1 Methodology

The empirical methodology used in this thesis is the general methods of moments (GMM). This method fits to the analysis of panel data with few time periods and many cross-sectional observations. The method allows that regression model includes a dynamic effect, i.e., lagged observation of the left-hand-side variable, and a set of independent variables, which might not be strictly exogenous. The GMM method can be used also in the presence of the fixed individual effects, heteroskedastcity, and autocorrelation within cross-sectional units.

The GMM estimator is developed by Holtz-Eakin et al. (1988). Arellano and Bond (1991) improved the model to the first-difference GMM estimator which has a high efficiency due to additional restrictions on covariance between regressors and the error term, also known as moment restrictions. Later Arellano and Bover (1995) and Bundell and Bond (1998) showed that the system GMM estimator is more efficient than the first-difference GMM estimator. The system GMM method can improve efficiency of estimators by introducing more instruments.

The GMM method fits for data in which dependent variables, left-hand-side fiscal variables, depend on their previous values. Zokalj (2016) states that public expenditure is persistent. It is unlikely that the public expenditure, such as pensions, changes significantly in the short run. As the intertemporal budget constraint shows, the public debt also depends on its past values. The debt level in the period *t* depends on a size of the debt in the previous period *t-1*. The interest payment depends on the debt of the previous period and the higher debt level entails higher interest payments.

A panel data enables to look at dynamic relationships better than a cross section data. The dynamic panel data is also better than a static method if fiscal variables tend to be persistent after controlling for the business cycle state. For example, public revenue is collected from the value added taxes and income taxes, which depend on the wages and the business cycles directly. Second reason to prefer the panel data to a cross sectional data is the presence of individual effects, which characterize the heterogeneity among the individuals.

Baum et al. (2003) mention that the GMM estimator has been seen as more efficient than IV estimator, when there is heteroskedasticity in the data. Estimates of IV method may be consistent while standard errors are not, and therefore, results are not reliable to interpret. The GMM method uses orthogonality conditions to enhance the efficiency in the presence of heteroskedasticity. (Baum et al., 2003) Time-invariant differences between countries causes heteroskedasticity in multi-country data.

The main regression model for the empirical research of this thesis is formed as follow:

$$f_{it} = \alpha f_{i,t-1} + \beta_1 x_{i,t} + \gamma_k z_{k,i,t} + \eta_i + \varepsilon_{i,t}$$

f_{it} = fiscal variable
$f_{i,t-1}$ = lagged dependent variable
$x_{i,t}$ = demographic variables
$z_{k,i,t}$ = vector of *k* control variables
η_i = country fixed effect (time-invariant)
$\varepsilon_{i,t}$ = error-term

Country is denoted by *i* and period by *t.* The persistence of data is characterized in two ways. A lagged fiscal variable, $f_{i,t-1}$, among the regressors represents the persistence of the fiscal variable and this causes autocorrelation in the model. Country fixed effect, η_i, characterizes the persistency within countries and the heterogeneity between the countries. The coefficient, β_1, shows a fiscal impact of the demographic change. A vector of coefficients, γ_k, captures controlled effects of *k* control variables on fiscal variables.

To produce a consistent estimator of β_1 the composite error, $v_{i,t} = \eta_i + \varepsilon_{i,t}$, which consist of time-invariant and time varying errors, is assumed to be uncorrelated with an explanatory variable, $x_{i,t}$ whereas the regressor $f_{i,t-1}$ is correlated with the error term which causes bias. To give an example, let us to think that in a year *t* a shock, which will lead to a higher public debt level, occurs in country *i*. This shock is not modelled, and the shock shows up in the error term. The country fixed effect will be higher for the whole time period and therefore, in the next year, *t+1*, the public debt and the country fixed effect will be both higher. Baltagi (2005) states that an OLS estimator will be biased and inconsistent due to correlation between a right-hand regressor and country fixed effects.

By using a fixed effects method the country fixed effects can be controlled, even though there will be still a chance for correlation between a regressor and an error term. In longer time series samples, the increasing number of observations may dampen the effect of one year shock on the country fixed effects and the endogeneity problem in the data. The fixed effects estimator also become consistent and a bias in the estimator decreases with higher T.

By taking first-differences and by using instrumental variables the country fixed effects can be controlled and the correlation between regressor and the remaining error can be handled. The regression model for differenced values of observations reads as

$$\Delta f_{it} = \alpha \Delta f_{i,t-1} + \beta_1 \Delta x_{i,t} + \gamma_k z_{k,i,t} + \Delta \varepsilon_{i,t}$$

In the first-difference model above the country fixed effects have been controlled for and $\Delta \varepsilon_{i,t}$ is assumed to be uncorrelated with $\Delta x_{i,t}$. The instrument, $f_{i,t-2}$, for $\Delta f_{i,t-1}$ is not correlated with $\Delta \varepsilon_{i,t}$ if the errors are not serially correlated. This instrumental variable estimation leads to consistent estimates of the parameters. As mentioned earlier by using as many moment conditions as available, the efficiency of the estimator can be improved. An increasing number of moment conditions is possible when using the GMM method and therefore, more efficient estimator can be created than by using IV method. Robust standard errors are used to handle the presence of heteroskedasticity and autocorrelation within panels.

6.2 Empirical research

In the empirical models we study the effects of the demographic change on two fiscal variables. The demographic change is captured by an old age dependency ratio (OADR), which has been used in many other studies, such as Zokalj (2016) and Afflatet (2018). The fiscal variables are the government pension expenditure and the public debt. No assumptions on the demographic change have been made in the next models. The testable hypotheses are based on the assumption of the fiscal effects that the population aging causes.

In the first model, the level of public debt, D_{it}, is explained by an old age dependency ratio, $OADR_{it}$, in addition to a set of control variables, Z_{kit}.

$$D_{it} = \alpha D_{i,t-1} + \beta_1 DR_{it} + \gamma_k Z_{kit} + \varepsilon_{it} \quad (1)$$

The parameter, β_1, describes the change in the public debt.

The hypothesis is that an estimate of the OADR effect on public debt is positive. A larger share of over 64 years old relative to the working age population increases old age-related expenditures while government revenues stay constant or decrease. Afflatet (2018) found a positive and significant coefficient for the old age dependency ratio of over 84 years old population,

whereas the effect of the old age dependency ratio of over 64 years old population was significant and negative in those European data. This means that a larger share of over 64 years old is related to the lower public debt in Europe and the change of over 84 years old population is associated with the higher public debt.

By using 5-year averages the parameter, β, captures the medium-run impacts. Zokalj (2016) calculates long-run effect as $\beta/(1-\alpha)$. The long-run effect of explanatory variable on left-hand side variable is higher when the estimate of the lagged left-hand side variable is larger. In other words the long-run effect of OADR is greater when the explained fiscal variable is more persistent.

In the second model the fiscal variable is the pension expenditures. The model reads as

$$Pex_{it} = \alpha Pex_{i,t-1} + \beta_1 DR_{it} + \gamma_k z_{k,i,t-1} + \varepsilon_{i,t} \quad (2)$$

The null hypothesis is for a positive and statistically significant estimate of OADR. The parameter β_1 describes the change in the pension expenditures when the old age dependency ratio changes. The positive estimate means that when the share of the over 64 years old population grows relative to the working age population, the pension expenditure increases too. Zokalj (2016) studies the effect on the old age pension expenditure and the results show positive and significant effects for the European Union's member states. This data set also includes the advanced countries, such as Japan, the United States and Canada. Later the results will show how interesting case Japan is due to the high debt level and relatively old age structure.

The old age dependency ratio may be a little problematic variable to be used for rawing conslusions on the effects of the age structure on the pension expenditure. The higher old age dependency ratio may intuitively mean that it leads to higher pension expenditure, but the higher ratio does not automatically mean that the number of over 64 years old people has grown. A rise of the ratio can be caused by also a decrease in the share of the working age population while the population of over 64 years old remain constant.

In the case of the public debt, the old age dependency ratio may fit more perfectly to describe the link between these variables. To consider the sustainability of public finances, the old age dependency ratio compares two important causally related varisbles. First, the larger share of the working age population is better for fiscal balance since the government is able to collect more revenues. Secondly, the higher share of over 64 years old population may stress the fiscal balance since the higher share of older population is assumed to increase the old-age related expenditures. As discussed in Chapter 3 when the expenditure exceeds the revenue, the deficit will be financed by borrowing. In this case the greater change in older population than the working age population leads to higher public debt.

Finally, the endogenicity of demographic variables in the model should be considered in order to use the system GMM model credibly. Variables of this data are observed in the medium run and the assumption of exogenicity is weak. Zokalj (2016) states that if the variables are observed yearly, the demographic variables can be assumed to be exogenous, but in the medium run the variables should be treated as an endogenous.

6.3 Data

The dataset includes 22 countries which are members of OECD. The countries are listed in Appendix C. Other members of OECD, which have joined later than 1985, have been left outside due to the lack of data. Observations start from year 1985 and end up the newest data from year 2018. The panel set is unbalanced. All variables are listed and described in Appendix D and summary statistics are reported in Appendix E.

All models include a fiscal variable, a demographic variable and control variables. The fiscal variables are the government debt and the pension expenditure. All fiscal variables are represented as in relation to GDP, which makes countries more comparable. There may be heterogeneity in levels of the fiscal variables among the countries. For example, the public debt may be at high level while the economy is growing fast. Data on the general government gross debt has been collected from IMF databases.

The pension expenditure data are collected from the OECD statistics. The pension expenditures consist of pensions, an early retirement pensions and other cash benefits. The pension expenditure includes all cash benefits that are provided to a retiree, who has reached the retirement age or fulfilled the necessary contribution requirements. The pension expenditure includes also early retirement benefits which are not related to unemployment. The benefits in kind, such as residental care or home-help service, are excluded from the data. As other fiscal variables the pension expenditure are measured as a percentage of GDP.

The population aging is represented by the old age dependency ratio (OADR). The OADR is determined by comparing a share of population at ages 65 or over to a share of working age population at ages of 15 to 64. Data is collected from the World Bank database. The OADR may be more adequate variable to measure macroeconomic effects of the demographic change than other demographic variables, such as fertility and mortality. These variables affect the population's age structure and an economy with a long lag. The OADR has also its own weaknesses. The ratio can grow besides that the population of over 64 grow and therefore, the implications of effects on old-age related expenditure may be difficult to make as mentioned earlier. To consider the

sustainability of the public finances in terms of fiscal balance or the public debt the OADR describes better the causality.

Control variables are the unemployment rate, an institutional quality measure, a trade openness indicator, and the real interest rate on the government bonds. The trade openness and the institutional quality are collected from the World Bank database. The institutional quality variable is a weighted average of four components which are the measures for control of corruption, a government effectiveness, political stability, and absence of violence. Indicator is defined on a scale from 0 to 2,5. The higher the value is, the more stable is the political stance or more efficient the government is, or less corrupted or violent the country is. Observations start from year 1996.

Data on the unemployment rate and the real interest rate has been collected from the IMF database. The interest rate on long term government bonds is inflation-adjusted resulting the series for real interest rate. For Norway and some other countries, the interest rate data are completed from the Norges Bank's database and the OECD statistics.

7 RESULTS AND ANALYSIS

Scatter plots in Figures 7 and 8 indicate a positive correlation between old age dependency ratio and both pension expenditures and public debt which is consistent with the null hypotheses of this research. Larger share of over 64 years old population raises the demand on pensions while longevity lengthens the period on retirement. The public debt will rise when total government expenditure has increased due to the higher pension expenditures without a sufficient increase in total government revenue.

Japan's relatively old age structure can explain outliers in both figures on the next page. The outliers of the scatter plot in Figure 8 show that pension expenditures have not increased substantially although the old age dependency ratio has been at high level. Later in Figure 9, we shall see how the pension expenditures in Japan have risen with the old age dependency ratio. In the case of the public debt, the outliers in Figure 7 reflect high debt level and old age dependency ratio at the same time. In Japan, the public debt has been at the highest level and the population has been relatively older than in other industrialized countries.

Because outliers may affect results of the empirical research, Japan has been excluded from further analyses to see if there is any basis for the conclusions posed above for the other countries. Intuitively, in the case of public debt without Japan in which the public debt has been at high level and the age structure has been relatively old, the magnitude of the main parameter estimate of interest will be small, or the effect may be insignificant for other countries. In the case of pension expenditures, the older age structure and relatively low pension expenditures in Japan may dampen the significance of the effect in all 22 OECD countries.

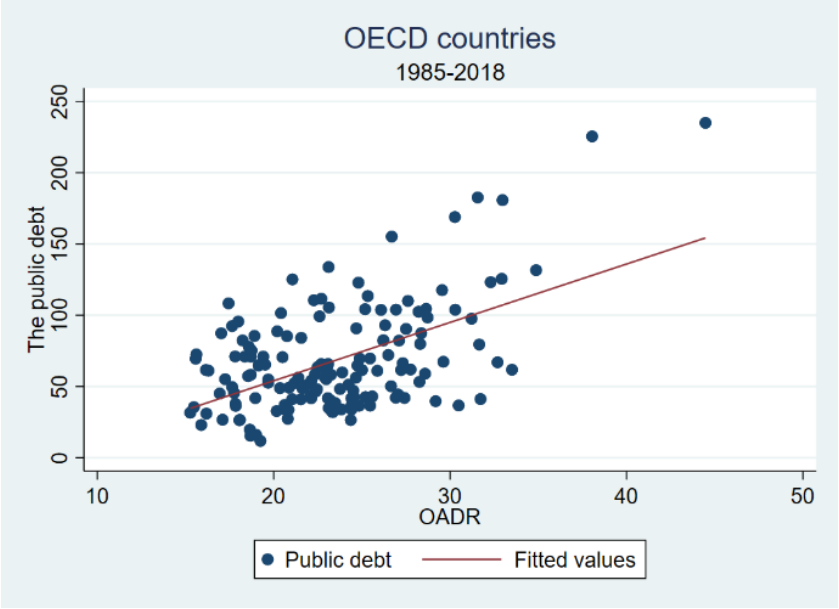

Figure 7. The public debt in 22 OECD countries
Source: Data from IMF database

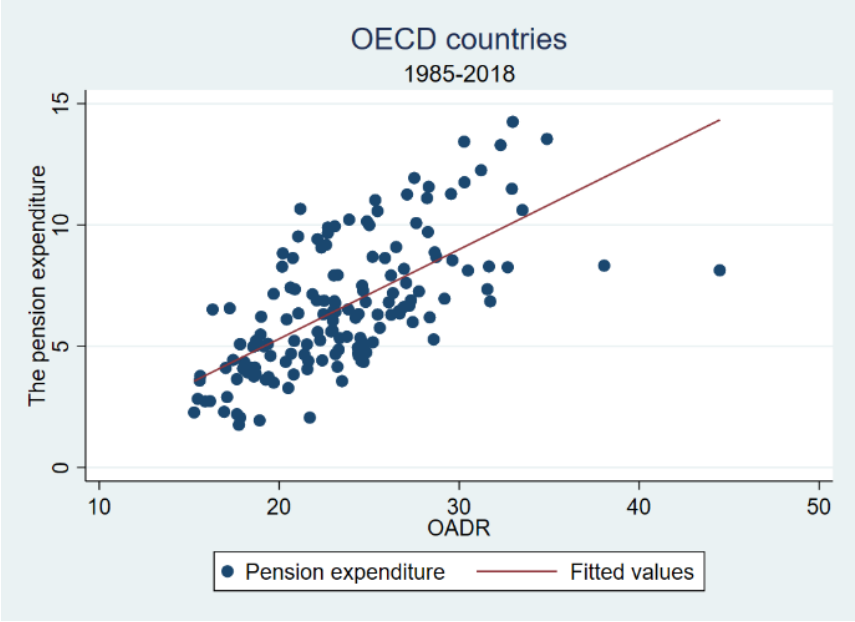

Figure 8. The pension expenditure in 22 OECD countries
Source: Data from OECD statistics

The pension expenditure

In the first model the total sample period from 1985 to 2018 has been divided into 7 subperiods. Hence, the observations are 5-year non-overlapping averages. Using 5-year averages the whole timeperiod can be utilized, but as a statistical requirement for the efficiency of GMM-estimation, the number of cross-sectional units (22) clearly exceed the number of time series observations (7). The whole time period with yearly observations increases the number of instruments, which cause some problems with GMM model. The panel unit root tests showed that the data with yearly observations contained unit roots, which will cause dynamic bias in the panel regressions. Regressions with yearly data showed that the parameter estimate on the lagged dependent variable was over 1.0. This is a sign of the dynamic bias in the panel data implying that the value of the dependent variable is accelerating the divergence away from equilibrium values.

Table 1 on the next page shows that an estimated value of the lagged pension expenditure for the 5-year average data is under one which implies statistically appropriate dynamics. The parameter estimates based on the GMM estimation are between the estimates from pooled OLS and fixed effects (FE) models. This is consistent with the theory that the fixed effects model tends to underestimate persistency whereas the pooled OLS model is overestimating it. (Bond, 2002) The estimate of the OADR is significant only in the fixed effects model with a positive and small estimate. The Hansen test is under 1.0 by collapsing instruments. If the Hansen test gives an exact value of 1.0, the estimates may be efficient but biased due to the instrument prolification. Using collapse in the xtabond2-procedure of Stata decreases the number of instruments which may fix this problem as it seems to work in all the following regressions. Table 1 shows one undesired result regarding the AR(2)-test for the autocorrelation in residuals which rejects the null hypothesis of no second order correlation at 5 % significance level. The regression results in Table 1 show only the persistence of the pension expenditure.

Table 1. 5-year averages of pension expenditures in 22 OECD countries, period of 1985-2018

Pension expenditure	**Pooled OLS**	**FE**	**GMM**
L.Pension expenditure	0.915***	0.372***	0.878***
	(0.0415)	(0.0921)	(0.102)
OADR	0.0395	0.116**	0.0279
	(0.0286)	(0.0352)	(0.0631)
YADR	-0.0383	-0.0401	-0.0562
	(0.0249)	(0.0509)	(0.0480)
Interest rate	0.0269	-0.0529	0.0539
	(0.0489)	(0.0419)	(0.0691)
Institutional quality	-0.433	-1.643***	-0.201
	(0.265)	(0.368)	(0.586)
Unemployment	0.0383	0.178***	0.0546
	(0.0236)	(0.0242)	(0.0346)
Trade openness	-0.000969	-0.00969	-0.00352
	(0.00202)	(0.00580)	(0.0022)
Observations	110	110	110
Groups		22	22
Instruments			45
R^2	0.951	0.848	
Hansen p-value			0.998
AR1 p-value			0.504
AR2 p-value			0.0255

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

The regression results in Table 2 on the next page are for the data without Japan. The estimate of the OADR is statistically significant. The old age dependency ratio in Japan is high, but the pension expenditure has not changed substantially. It seems that in the data with rest of the countries the effect of the old age dependency ratio on the pension expenditure is significant. Unemployment has also a positive and significant effect on the pension expenditure. Increase in the unemployment may encourage an unemployed person at older age to retire earlier. However, the effect of OADR is larger than the effect of unemployment on the pension expenditure. A significant lagged value of the dependent variable indicates persistence of the pension expenditure. A value of the lagged dependent variable is lower than in first regression which means lower persistence of the pension expenditure.

Table 2. 5-year averages of pension expenditures in OECD countries (Japan excluded), period of 1985-2018

Pension expenditure	**Pooled OLS**	**FE**	**GMM**
L.Pension expenditure	0.895***	0.361***	0.668***
	(0.0460)	(0.0912)	(0.137)
OADR	0.0683*	0.140*	0.178*
	(0.0310)	(0.0533)	(0.0802)
YADR	-0.0280	-0.0301	-0.0381
	(0.0262)	(0.0538)	(0.0577)
Interest rate	0.0357	-0.0457	0.0312
	(0.0496)	(0.0436)	(0.0662)
Institutional quality	-0.414	-1.386*	-0.217
	(0.267)	(0.494)	(0.414)
Unemployment	0.0352	0.176***	0.0951*
	(0.0241)	(0.0243)	(0.0375)
Trade openness	-0.00112	-0.0107	-0.00269
	(0.00215)	(0.00621)	(0.00277)
Observations	105	105	105
Groups		21	21
Instruments			33
R^2	0.953	0.845	
Hansen p-value			0.975
AR1 p-value			0.404
AR2 p-value			0.0697

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

The medium-run effect of older age structure on the pension expenditure is 0.178. Long-run effect based on the calculations of Zokalj (2016) is 0.54, which is higher than medium-run effect due to persistence of the pension expenditure. Contrary to the first regression, in this model AR(2)-test do not reject null hypothesis of no second order autocorrelation at 5 % significance level.

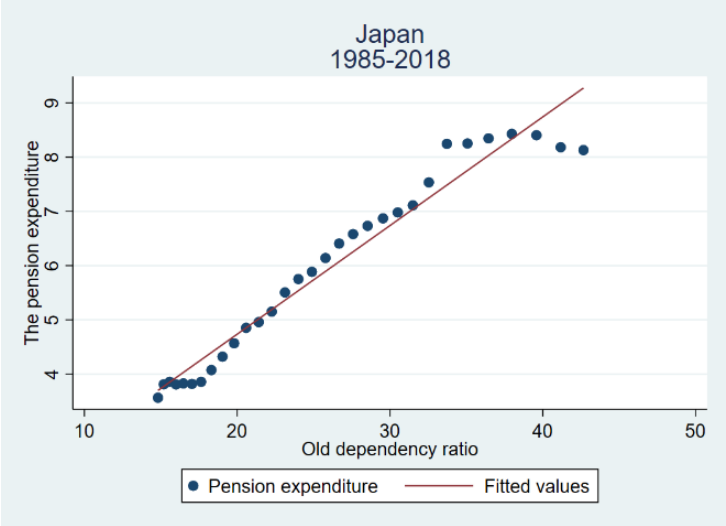

Figure 9. Pension expenditure of Japan

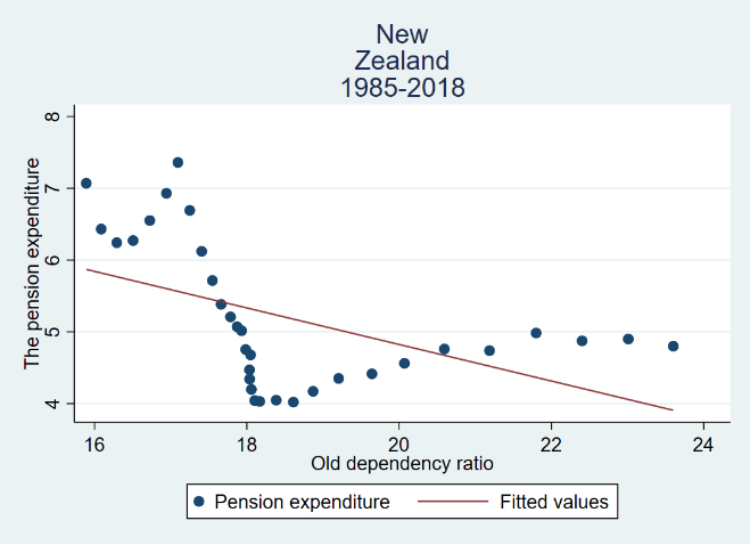

Figure 10. Pension expenditure of New Zealand

Figure 11. Pension expenditure of Finland

In the case of Finland (Figure 11) increases in pension expenditures, when old age dependency ratio grows, have been quite steady at the higher OADR levels. When the OADR is under 25, there is more variation. In the case of Japan (Figure 9), the pension expenditures seem to grow steadily with the old age dependency ratio until the OADR reaches a certain level. After this level, the pension expenditures stop increasing and stay at the same level despite growing old age dependency ratio. Based on the figures, Japan might affect a magnitude of the effect of the age structure on the pension expenditure. This effect is proved above when Japan was excluded from the data and the parameter of the OADR became significant and greater than in the first regression. In New Zealand the correlation between OADR and the pension expenditures is negative which one can see from Figure 10. This is arguing against the hypothesis that older age structure leads to higher pension expenditures. One explanation can be the effective retirement age, which was 70 in 2018.

The public debt

Table 3. 5-year averages of public debt in 22 OECD countries, period of 1985-2018

Public debt	**Pooled OLS**	**FE**	**GMM**
L.Public debt	0.888***	0.442**	0.566*
	(0.0702)	(0.131)	(0.288)
OADR	0.604	1.882*	2.138*
	(0.456)	(0.723)	(0.963)
YADR	-0.307	-0.831	1.896
	(0.523)	(1.031)	(1.128)
Interest rate	-0.500	-0.368	1.057
	(1.052)	(1.441)	(2.362)
Institutional quality	-7.486	0.452	-4.657
	(5.684)	(16.74)	(19.74)
Unemployment	1.280*	4.636***	2.907
	(0.558)	(0.834)	(1.634)
Trade openness	-0.0956	-0.0810	0.00943
	(0.0774)	(0.165)	(0.111)
Observations	110	110	110
Groups		22	22
Instruments			38
R^2	0.854	0.781	
Hansen			0.921
AR1 p-value			0.267
AR2 p-value			0.145

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 3 shows effects of an old age dependency ratio on a public debt. An estimate of the lagged dependent variable is positive and significant which supports the assumption that the public debt depends on its past values. Pooled OLS model gives the highest parameter of the lagged dependent variable and fixed effects model gives the lowest parameter. The estimate of GMM model sets between these models as in previous regressions. The parameter of the OADR is positive and significant in FE and GMM models. The estimate is over two in GMM model, which means that when the OADR increases by one percent, the public debt grows by 2.138 percentage point in the medium-run. In the long-run the effect is 4.93, which is much higher than the medium-run effect, such as in the case of the pension expenditure, due to persistence of the dependent variable. Statistics for this model do not show any concerning signs. Hansen's test of

instruments validity is under 1.0. The AR-tests do not reject null hypothesis, which means that there is not the first or second order autocorrelation.

Table 4. 5-year averages of public debt in OECD countries (Japan excluded), period of 1985-2018

Public debt	**Pooled OLS**	**FE**	**GMM**
L.Public debt	0.653***	0.376**	0.490**
	(0.0874)	(0.129)	(0.152)
OADR	0.498	0.914	0.921
	(0.459)	(0.703)	(0.869)
YADR	-0.00921	-0.841	0.785
	(0.487)	(0.973)	(0.883)
Interest rate	-0.148	-0.775	0.340
	(1.017)	(1.309)	(2.079)
Institutional quality	-17.12**	-20.37	-8.872
	(6.019)	(13.17)	(8.607)
Unemployment	1.698**	4.542***	3.662**
	(0.519)	(0.790)	(1.321)
Trade openness	0.0180	-0.0552	-0.0546
	(0.0790)	(0.171)	(0.0587)
Observations	105	105	105
Groups		21	21
Instruments			39
R^2	0.830	0.737	
Hansen p-value			0.990
AR1 p-value			0.0549
AR2 p-value			0.0816

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Without Japan value of OADR lowered significantly and the estimate became insignificant. It seems that there is not significant relationship between the public debt and old age dependency ratio on the rest of the countries. Persistence of the public debt is lower than in the first model. Unemployment has a positive and significant effect on the public debt.

Young age dependency ratio has not significant effects on either of fiscal variables. Interest rate is not significant determinant on any model. Institutional quality does not also show a strong effect on these fiscal variables.

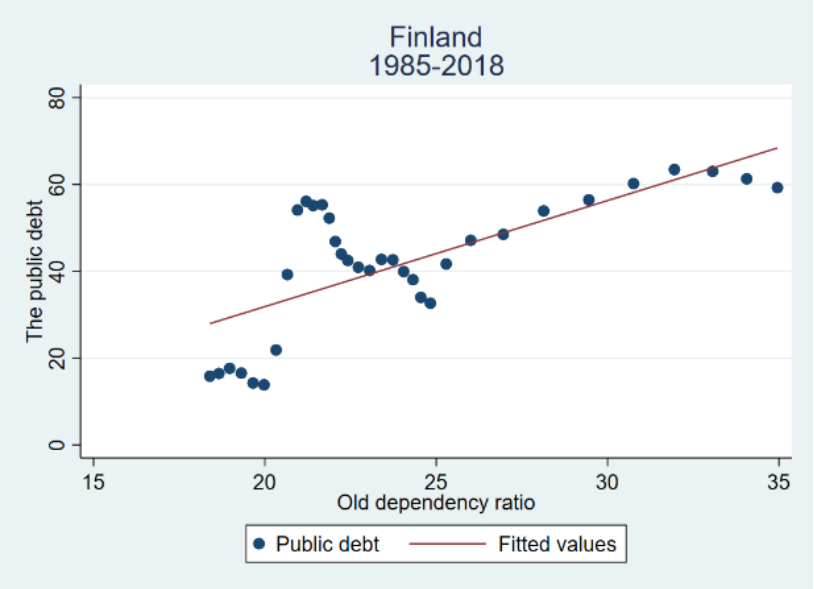

Figure 12. Public debt of Finland

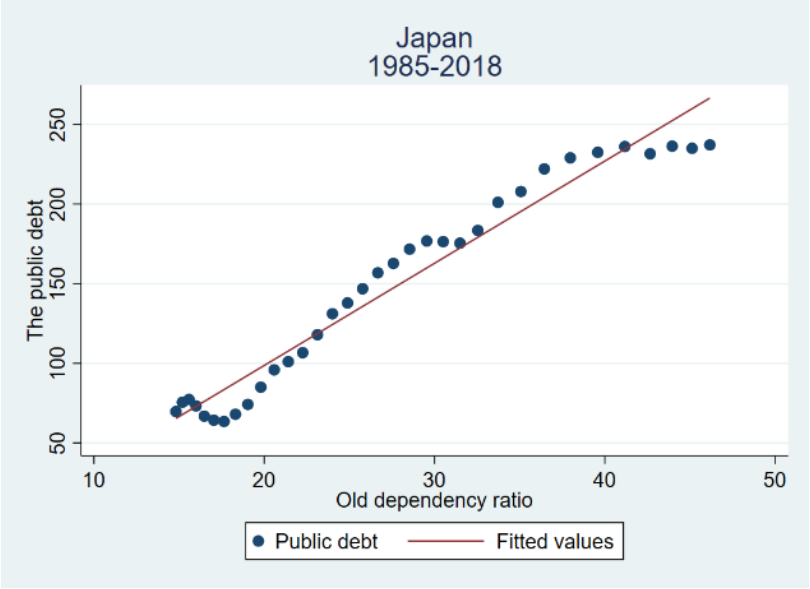

Figure 13. Public debt of Japan

Comparing effects of OADR on public debt and pension expenditure, regressions with data in which Japan has excluded, the effect of older age structure is only significant on the pension expenditure. Contrary, first regressions with Japan show that higher OADR leads to significant effects only on the public debt. For that reason, Japan would be interesting country to investigate by itself.

There are two things that should be considered when making conclusions of Japan. As mentioned on section 4.2, in Japan a poverty reliefing old-age safety-net benefit is much lower than in many other OECD countries. Secondly, the effective retirement age is around 70 in Japan as mentioned in section 4.4. This would mean that a higher share of the older age groups does not increase the government expenditure. One explanation is that many people at age over 64 years old continue working. For instance, as mentioned on section 4.3 in 2018 almost half of the population at ages from 65 to 69 still participated in workforce. This would increase the revenue rather than the expenditure. Although in Figure 13 the public debt increases steadily with the OADR, it should be considered that there might be some other variables that increase the debt levels in Japan than the older age structure.

8 DISCUSSION

Reforming the public pension system is important especially in countries with aging population and governments in which the social security system has a broad coverage. It is reasonable to raise the retirement age when the life expectancy increases continually. People at older ages should be encouraged to work rather than take early retirement. The results show that increasing unemployment has a positive effect on the pension expenditure. One explanation for this might be that unemployed people at older ages have an incentive to take the early retirement when it is possible. Japan is an exception in this. Almost half of the people at ages from 65 to 69 are participating in the labor force. One reason could be that the public pension system does not provide as strong poverty reliefing social security for elderly people as in many other developed countries.

In Chapter 2 the figures show that many developed countries have old age structure, or it has been projected to get older in the future. Contrary to many European countries, the working age population in the United States and Canada is growing. The age structures have similarities and differences amongst the developed countries and the aim of this study is not to make conclusions about it. The interest is in the link between the demographic change and the government's budget. This study finds significant results of the effects on both the public debt and the pension expenditures, which supports some earlier empirical findings. However, most of the significant results of the effects on the government budget has found from the projected changes in the future.

This study finds a positive correlation between the old age dependency ratio and both the pension expenditure and the public debt. Results of regressions for 22 OECD countries are significant only in the case of the public debt. This effect disappears without Japan. This supports the argument of Afftalet (2018) that the effects of the population aging on the public debt in Europe have only a little empirical support so far. Until now, the governments seem to manage the demographic change without mounting the public debt, althought Afftalet (2018) does not argue that this would not be a challenge in the future.

The significant effect of the population aging on the public debt disappears when Japan is excluded from the estimation. Both the old age dependency ratio and the public debt has been at a high level in Japan, which apparently affects the results. As mentioned in Chapter 5, Kitao (2015) projects that the demographic change will lead to a budget imbalance in Japan.

Kitao (2015) also project that the large cohort of retired people, longevity and lower fertility will affect the pension and the health care expenditures in Japan. Until 2018, this study finds the significant effect of the older age structure on the pension expenditure only without Japan. In the figure of Japan's pension expenditures showed that the expenditures have not grown as much when the old age dependency ratio is at high level. The reason for relatively low pension expenditure in Japan may be the policy to provide a social security for elderly population.

There are signs that changes in the age structure has affected the pension expenditures, especially recently in Europe. Zokalj (2016) finds a small growth in the pension expenditures in European countries, which supports the findings of this study for 21 OECD countries. However, Yoon et al. (2014) do not find any significant evidence that the older age structure has increased the government expenditure in 30 OECD countries from 1960 to 2013. The strong link between the old age dependence ratio and the pension expenditure in Europe may be explained by the pension system, which covers younger people than, for example, in New Zealand and Japan and by the older age structure than in Canada and the United States.

In the case of the public debt, the population aging may not be only variable that causes or maintains the higher public debt levels. The effects of the demographic change on the public debt seem to be insignificant according to results on the Table 4. Figure 13 indicates that the public debt has some connection with the older age structure in Japan. However, Yoon et al. (2014) find that the older age structure has affected the revenue and the fiscal balance positively in Japan during the period of 1960-2013, which argues against to that the high public debt is caused by older age structure.

As the earlier empirical research, this study finds some evidence of the link between an older age structure and fiscal variables. Any common conclusions are difficult to make. It is more reasonable to consider countries' fiscal policy and the needs for reforms individually when the age structure and government's policy to provide a social security and public services differ substantially between these countries. As Goldstein and Kluge (2016) emphasize the importance of new policies to absorb the negative effects of the demographic change in the future, this study also argues that some countries need to reconsider the services for especially the older population that are provided by the government. A real challenge is to provide elderly population with a social security which is financially sustainable, poverty reliefing and fair for all age groups over the generations.

REFERENCES

Afflatet, N. (2018). The Impact of Population Ageing on Public Debt: A Panel Data Analysis for 18 European Countries. International Journal of Economics and Financial Issues, 8(4), 68.

Arellano, M. and Bond, S., 1991. Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. The Review of Economic Studies, 58(2), pp. 277-297. doi: 10.2307/2297968

Arellano, M. and Bover, O., 1995. Another look at the instrumental variable estimation of error-components models. Journal of Econometrics, 68(1), pp. 29-51. doi: 10.1016/0304-4076(94)01642-D

Attanasio, O., Kitao, S., & Violante, G. L. (2007). Global demographic trends and social security reform. Journal of monetary Economics, 54(1), 144-198.

Baum, C. F., Schaffer, M. E., & Stillman, S. (2003). Instrumental variables and GMM: Estimation and testing. The Stata Journal, 3(1), 1-31.

Bénassy-Quéré, A., Coeuré, B., Jacquet, P. & Pisani-Ferry, J. (2010). Economic Policy; Theory and Practice, Oxford University Press, New York.

Blundell, R. and Bond, S., 1998. Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics, 87, pp. 115-143.

Bond, S. R. (2002). Dynamic panel data models: a guide to micro data methods and practice. Portuguese economic journal, 1(2), 141-162.

Braun, R. A., & Joines, D. H. (2015). The implications of a graying Japan for government policy. Journal of Economic Dynamics and Control, 57, 1-23.

Börsch-Supan, A., Härtl, K., & Ludwig, A. (2014). Aging in Europe: Reforms, international diversification, and behavioral reactions. American Economic Review, 104(5), 224-29.

Callen, T., Batini, N. and Spatafora, N., 2004. How will demographic change affect the global economy. Chapter 3: an.

Chamley, C. (1986). Optimal taxation of capital income in general equilibrium with infinite lives. Econometrica: Journal of the Econometric Society, 607-622.

Chen, D. H. (2004). Population age structure and the budget deficit. The World Bank.

Conesa, J. C., Kitao, S., & Krueger, D. (2009). Taxing capital? Not a bad idea after all!. American Economic Review, 99(1), 25-48.

De Nardi, M., Imrohoroğlu, S., & Sargent, T. J. (1999). Projected US demographics and social security. Review of Economic dynamics, 2(3), 575-615.

Erosa, A., & Gervais, M. (2002). Optimal taxation in life-cycle economies. Journal of Economic Theory, 105(2), 338-369.

European Commission, 2015. The 2015 Ageing Report: Economic and budgetary projections for the 28 EU Member States (2013-2060). Available at: http://ec.europa.eu/economy_finance/publications/european_economy/2015/pdf/ee3_en.pdf

European Comission. (2019). Vade Mecum on the Stability and Growth Pact. 2019 edition. European Economy. Institutional Paper 101.

Fehr, H., Jokisch, S., & Kotlikoff, L. J. (2008). Fertility, mortality and the

developed world's demographic transition. Journal of policy modeling, 30(3), 455-473.
Fehr, H., Jokisch, S., & Kotlikoff, L. (2003). The developed world's demographic transition: The roles of capital flows, immigration, and policy. National Bureau of Economic Research.
Fuster, L., İmrohoroğlu, A., & İmrohoroğlu, S. (2007). Elimination of social security in a dynastic framework. The Review of Economic Studies, 74(1), 113-145.
Giavazzi, F., Amighini, A., & Blanchard, O. J. B. (2010). Macroeconomics: a European perspective. Financial Times Prentice Hall.
Goldstein, J. R., & Kluge, F. (2016). Demographic pressures on european unity. Population and Development Review, 299-304.
Guest, R., McDonald, I., 2000. Population ageing and projections of government social outlays in Australia. Aust. Econ. Rev. 33, 49–64.
Holtz-Eakin, D., Newey, W. and Rosen, H. S., 1988. Estimating Vector Autoregressions with Panel Data. Econometrica, 56(6), pp. 1371-1395.
İmrohoroğlu, S., Kitao, S., & Yamada, T. (2016). Achieving fiscal balance in Japan. International Economic Review, 57(1), 117-154.
Jung, J., Tran, C., & Chambers, M. (2017). Aging and health financing in the US: A general equilibrium analysis. European Economic Review, 100, 428-462.
Junttila, J. P. (2019). Discounting the Deficit into Debt: the 3D Dilemma for the OECD Countries. Available at SSRN 3019952.
Katagiri, M., Konishi, H. and Ueda, K., 2014. Aging and Deflation from a Fiscal Perspective. Federal Reserve Bank of Dallas, Working Paper, No. 218.
King, P. and Jackson, H., 2000. Public Finance Implications of Population Aging. Department of Finance Working Paper, No. 2000-08.
Kitao, S. (2014). Sustainable social security: Four options. Review of Economic Dynamics, 17(4), 756-779.
Kitao, S. (2015). Fiscal cost of demographic transition in Japan. Journal of Economic Dynamics and Control, 54, 37-58.
Kotlikoff, L. J., Smetters, K., & Walliser, J. (2007). Mitigating America's demographic dilemma by pre-funding social security. Journal of monetary Economics, 54(2), 247-266.
Kudrna, G., Tran, C. and Woodland, A., 2015. The Dynamic Fiscal Effects of Demographic Shift: The Case of Australia. Economic Modelling, 50, pp. 105-122.
Labrador, I. and Angona, F., 2003. Fiscal illusion, fiscal consolidation and government expenditure composition in the OECD: a dynamic panel data approach. Universidad de Laguna.
Lee, R. D. (2014). Macroeconomic consequences of population aging in the United States: Overview of a national academy report. American economic review, 104(5), 234-39.
Nishiyama, S. (2015). Fiscal policy effects in a heterogeneous-agent OLG economy with an aging population. Journal of Economic Dynamics and Control, 61, 114-132.

OECD Government at a Glance 2019 (a).
OECD Pensions at a Glance 2019 (b).
OECD Pensions Outlook 2018.
Piggott, J., & Woodland, A. (Eds.). (2016). Handbook of the economics of population aging. Elsevier.
Rouzet, D., Sánchez, A. C., Renault, T., & Roehn, O. (2019). Fiscal challenges and inclusive growth in ageing societies. OECD Economic Policy Paper.
Schwarz, A. M., Arias, O. S., Zviniene, A., Rudolph, H. P., Eckardt, S., Koettl, J., & Abels, M. (2014). The inverting pyramid: Pension systems facing demographic challenges in Europe and Central Asia. The World Bank.
Tuomala, M. (2009). Julkistalous. Gaudeamus.
Wickens, M. (2012). Macroeconomic theory: a dynamic general equilibrium approach. Princeton University Press.
Wolf, D. A., & Amirkhanyan, A. A. (2010). Demographic change and its public sector consequences. Public Administration Review, 70, s12-s23.
Yoon, J.-W., Kim, J. and Lee, J., 2014. Impact of Demographic Changes on Inflation and the Macroeconomy. IMF Working Paper 14/210.
Žokalj, M. (2016). The impact of population aging on public finance in the European Union. Financial theory and practice, 40(4), 383-412.

APPENDIX A

The nominal budget constraint is the form of

$$p_t G_t - p_t T_t + r_{t-1}^n p_{t-1} B_{t-1} = p_t B_t - p_{t-1} B_{t-1}. \quad (1)$$

In equation p_t denotes the price level, r_{t-1}^n is the nominal rate of interest on the public debt from period $t-1$ to period t. B_{t-1} is the real public debt at the end of previous period. The nominal public expenditure is denoted as $p_t G_t$, and the nominal public revenue as $p_t T_t$.

As Junttila (2019) states that a Ricardian system assumes the monetary actions are not considered as a solution to fund the deficit. Equation (1) embodies that the deficit must be financed, for example, by households and firms. The debt ratio, the expenditure and the revenue are observed at the period *t* and at the former period *t-1*. Wickens (2012) considers these fiscal variables at periods of *t* and *t+1* while demonstrating the fiscal stance.

Left side of equation (1) explains the deficit more detailed. The deficit is a result of expenditure which exceeds revenue at the period *t* with former period's interest payments of public debt added on it. Right side of equation (1) is a difference of debt between two periods. Left-hand-side deficit is financed by right-hand-side public debt. Rearranging equations (1) by shifting interest of previous debt to right side:

$$p_t G_t - p_t T_t = p_t B_t - (1 + r_{t-1}^n) p_{t-1} B_{t-1}.$$

Next nominal budget constrain is formated to real budget constrain by dividing fiscal variables by nominal gross domestic product. To get the real public expenditure the nominal expenditure is divided by nominal GDP, $p_t G_t / p_t Y_t$ and noted with smaller case letter, g_t. To do this for all terms, we get equation in form:

$$g_t - \tau_t = b_t - \frac{(1 + r_{t-1}^n) p_{t-1} B_{t-1}}{p_t Y_t}$$

Growth of real GDP can be defined as $Y_t = (1 + z) Y_{t-1}$.

$$g_t - \tau_t = b_t - \frac{(1 + r_{t-1}^n)}{(1 + z)} \frac{p_{t-1}}{p_t} \frac{B_{t-1}}{Y_{t-1}}$$

The proportional change in the general price level index can be noted as $\frac{p_t}{p_{t-1}} = 1 + \pi_t$. The real rate of interest on public debt (ex post) can be noted as

$$\frac{1 + r_{t-1}^n}{1 + \pi_t} = 1 + r_{t-1}$$

The last form (2) demonstrates government real budget constraint in which the former period's debt is affected by real interest rate and the growth of GDP:

$$g_t - \tau_t = b_t - \left(\frac{1+r_{t-1}}{1+z}\right) b_{t-1}. \quad (2)$$

APPENDIX B

Previous empirical research.

	Details	Results	Effects of larger share of the older population
Afflatet (2018)	18 European countries 1980-2015	No empirical evidence that population aging has affect public debt until 2015.	Not significant correlation between OADR and change in public debt
Yoon et all. (2014)	30 OECD countries 1960-2013	Not significant results for OECD countries. Effect of higher share of elderly population is greater on expenditure than revenue.	In Japan effect of elderly population is positive and significant on budget balance and revenue. The effect on expenditure is negative.
Zokalj (2016)	25 EU countries 1995-2014	The old-age dependency ratio has larger long-term effect on pension expenditures than social protection expenditure.	Positive effect of old-age dependency ratio on old-age pension expenditures, social protection expenditures, and total government expenditure and revenue. The effect is larger on expenditure than revenue. Negative effect on budget balance.
Labrador and Angona (2003)	26 OECD countries 1970-1997		Effect of elderly population is positive on social security and health care expenditures.
Kudrna et all. (2015)	Australia, projection to 2050	The aging population leads to decreases in the labor market activities.	Larger share of population aging increases old age-related spending.
Chen (2004)	55 developed and developing countries, period of 1975-1992		Larger share of older population has negative effect on the budget surplus in developing countries.

APPENDIX C

Countries in empirical research:

OECD countries
Austria Australia Belgium Canada Denmark Finland France Germany Greeze Iceland Ireland Italy Japan Netherlands New Zealand Norway Portugal Spain Sweden Switzerland United Kingdom United States

APPENDIX D

Description of variables

Variable	Description	Source
Inflation	Consumer price index, annual percentage.	The World Bank, World Development Indicators
Institutional quality	The average of five dimensions of governance: Control of corruption, government effectiveness, political stability and absence of violence/terrorism, regulatory quality, rule of law. On a scale of 0 to 2,5. IQ= (CC+GE+PS+RQ+RL)/5	The World Bank, Worldwide Governance Indicator
Old-age dependency ratio (OADR)	Old-age dependency ratio. The ratio of over 64 years old to working age population at ages 15-64.	The World Bank, World Development Indicators
Pension expenditure	Public old-age pensions, cash benefits: Pensions, early retirement pension, other cash benefits. In percentage of GDP.	OECD.stat Social Protection and well-being, Social expenditure
Public debt	General government gross debt. In percentage of GDP.	IMF World Economic Outlook, IMF Historical Public Debt Database
Real interest rate	The nominal interest rate of the long-term government bonds (percent per annum) extracted by inflation.	International Financial Statistics (IFS) Norway: Norges Bank Japan, Switzerland, New Zealand: OECD.stat
Trade openness	The sum of exports and imports of goods and services. In percentage of GDP.	The World Bank, World Development Indicators
Unemployment rate	The number of unemployed persons as a percentage of the labor force.	IMF World Economic Outlook
Young-age dependency ratio (YADR)	Age dependency ratio, young. The ratio of under 15 years old to working age population at ages 15-64.	The World Bank, World Development Indicators

APPENDIX E

Table 5. Summary statistics

Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Public debt	748	67.53	36.97	9.69	237.13
Government expenditure	706	44.83	7.91	25.31	68.03
Pension expenditure	676	6.40	2.56	1.56	14.50
Old age dependency ratio	748	23.27	4.80	14.82	46.17
Young age dependency ratio	748	27.58	4.69	20.16	50.39
Unemployment	748	7.41	4.24	0.44	27.48
Trade openness	748	70.88	35.06	16.01	226.04
Institutional quality	440	1.44	0.41	0.05	2.049
Real interest rate	733	3.14	2.62	-9.61	12.85