UCLouvain

LOUVAIN
School of Management

Louvain School of Management

The effects of the current population ageing phenomenon on European economic markets

Author : **Lionel Jaume**
Supervisor : **Leonardo Iania**
Academic year 2018-2019

Acknowledgements

As a preface, I would like to thank all the people who helped and encouraged me during the realisation of this master thesis.

I wish to thank my academic supervisor, Pr. Leonardo Iania, for the quality of his supervision and his precious guidance throughout the completion of this work.

I would also like to give special thanks to my mother, Anne Scieur, who read this work multiple times and to my sister, Diana Jaume, who helped me by giving rich advice.

Finally, I must express my very profound gratitude to my family and my friends for providing me with constant support and encouragement throughout my years of study and through the sometimes perilous process of writing this thesis.

Abstract

Developed countries, including European ones, have been facing a major demographic phenomenon for several years: the ageing of their populations. This phenomenon can mainly be explained by a fall in fertility rates leading to a slower population growth but also an increase in life expectancy. The numerous baby-boomers reaching retirement age also have a role to play in this situation.

While the economic health of European countries has been causing concern lately, the question in the minds of many economists has been the following: is there an effective relationship between the current economic slowdown and the ageing population in developed countries? Even if there have been many efforts to find a simple answer to this issue, it is still a matter of debate.

This thesis aims at contributing to the answer of this question by analysing demographic and economic data from a sample of nine countries located in the euro area. An econometric model is then used to find a possible relationship between different demographic factors characterizing population ageing and four main economic factors developed in this research: Gross Domestic Product (GDP) per capita growth, debt-to-GDP ratio, household saving rates and inflation. Overall, our results show evidence of a negative relationship between population ageing and economic factors.

Keywords: population ageing, demographics, European economy, secular stagnation

Table of contents

Introduction

It is a well-known fact that populations of developed countries, including all European countries, have been ageing rapidly over the last few years. This phenomenon is characterized by a shift in the age structure of populations. The proportion of young people is declining while the proportion of older people (often considered as people over 65) is steadily growing. In most of those countries, this situation is seen as the consequence of the baby-boom chapter that happened in the post-war period. Between the end-1940s and the late-1960s, the fertility rates in many countries of the Western world increased significantly and persistently while the world had previously been stuck in a phase where fertility rates and mortality rates were lower than never. The struggle that led to our ageing populations is that "baby-boomers", people born during the baby-boom period, are now retiring or, at least, approaching the age of retirement. As baby-boom was followed by a new decrease in fertility rates, the share of elders compared with middle-agers and young people is increasing every year, and the situation is not supposed to reverse in the next decades given the current and projected demographic movements.

The relationship that exists between the economic health of a country and its demographic changes has been at the centre of many discussions across time. One of the first theories was developed in 1939 by Alvin Hansen, when he mentioned the concept of "secular stagnation" which was substantially due to a slowing population growth. The secular stagnation concept defined the economic situation at that time which was characterized by a low economic growth, coupled with unemployment and underutilized resources. According to Hansen, a downshift in demography leads to low investment and excess savings, which imply a downward pressure on real interest rates. While this theory started to fade due to a recovery of the economic situation, partly due to World War II and the baby-boom, it came back a few years ago in the minds of economists as an explanation of the current economic slowdown. Indeed, many developed countries are facing, besides population ageing, a period of low economic growth and numerous authors (such as Bobeica, Lis, Nickel & Sun (2017); Ferrero, Gross & Neri (2017) and many others) have found demographic changes being one of the main forces leading to this situation.

The challenge is to understand what are the transmission channels from ageing population to economic variables. Theoretically speaking, an ageing society firstly has an impact on total savings. A simple theory that helps to understand that statement is the life-cycle theory. This one suggests that, during their life-cycle, individuals adapt their savings and consumption behaviour in order to smooth their consumption over lifetime. In general, the young and the elderly tend to save less than working-age people who earn wages and save to finance their future consumption. (Bobeica et al., 2017) However, as life expectancy is increasing, older people need to be certain of having enough savings to support their higher consumption when approaching the end of their lives. This could bring higher saving rates than expected, pushing real interest down. Besides that, labour market is also impacted by an ageing population. Indeed, labour supply decreases as more workers are beginning to retire and labour productivity also gets negatively impacted. (Nerlich & Schroth, 2018) All of these factors tend to affect most of the economic variables negatively and to support the hypothesis of a secular stagnation.

In order to understand how Europe can be impacted by the emergence of this "greying" population, it is interesting to take Japan as an example. Japan has been the first country to suffer from this situation as it is considered as one of the world's oldest societies. The country is indeed ageing in an extremely rapid way, as its ratio of the population over 65 to the population between 15 and 64 has been increasing since 1990 at a steady pace. This is mainly due to its life expectancy, which is the highest in the world, and a negative population growth. (Romel, 2018) This phenomenon has been accompanied by a period of recession, due to a fall in Japan's inflation and output at the same time. (Canon, Kudlyak & Reed, 2015) As European countries are currently facing similar demographic trends, we cannot rule out that a same economic recession could happen quite quickly.

The objective of this thesis is to offer a better understanding of population ageing and to raise the question of its effective impacts on European economic markets. In order to do so, we will use demographic and economic statistics coming from several European countries, or more precisely countries from the euro area, and perform a model which will allow us to estimate the different relationships that could exist between those variables. We will mainly focus on four economic variables: Gross Domestic Product (GDP) per capita, debt-to-GDP, household saving rates and inflation.

In the following parts of this thesis, we first conduct a literature review to give some backgrounds about the phenomena at stake in our research, namely population ageing and secular stagnation. Findings from previous studies conducted to find links between these two are also highlighted. Secondly, we present our data and the methodology used to perform our model using those data. Afterwards, the results from this model are presented and followed by a discussion. Finally, we conclude our thesis with a summary and some recommendations for future prospective researches.

Section I : Literature review

Chapter I : The demographic situation in European countries

In this chapter, we will describe the demographic position in which European countries are standing at the moment, substantially characterized by the ageing of their population. Some first figures will help to understand the importance of this phenomenon. They will be followed by a short presentation of the reasons that led to this struggling situation. Finally, we will end up with a description of potential future demographic trends made on the basis of projections realised by the European Commission.

1.1.1 The population ageing phenomenon

Some figures

There are several elements proving a clear ageing of the population in some part of the world, and even more importantly in Europe.

First of all, the most obvious evidence is the upward trend in the median age across European countries. As Figure 1 shows, the median age in the European Union increased from 38.6 years to 43.1 years during the period between 2002 and 2018. That means that, in average, people in the EU were in 2018 4.5 years older than they were 16 years earlier. Besides that, this median age rise has been observed in most of the European countries and therefore can be considered as a general trend. The Euro Area is even more impacted by the phenomenon, its median age growing from 39.1 to 43.1 years. Another piece of evidence that expresses how the age structure has changed in Europe is the evolution of the population pyramids. Figure 2 displays how the bottom of the pyramid has gotten narrower over the years, reflecting the weaker representation of young and middle-aged people in the EU population in 2018 compared to 2003. On the other hand, older men and women seem to be much more represented than they were 15 years before. (Eurostat, 2019a)

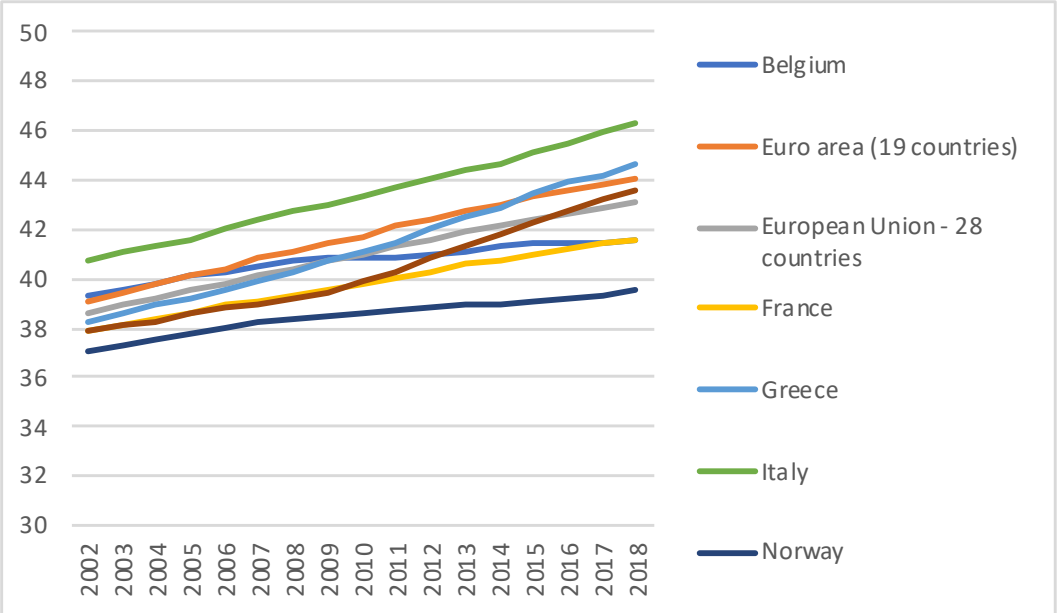


Figure 1. Evolution of median age between 2002 and 2018. Data retrieved from *the Eurostat database.*

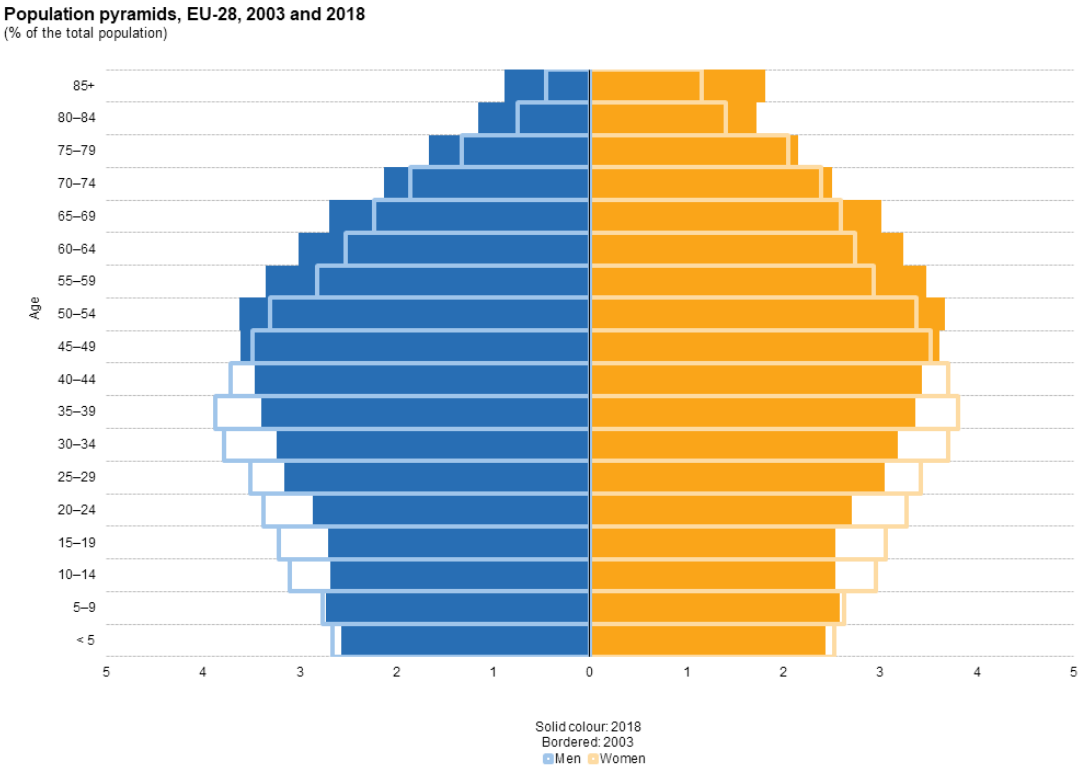
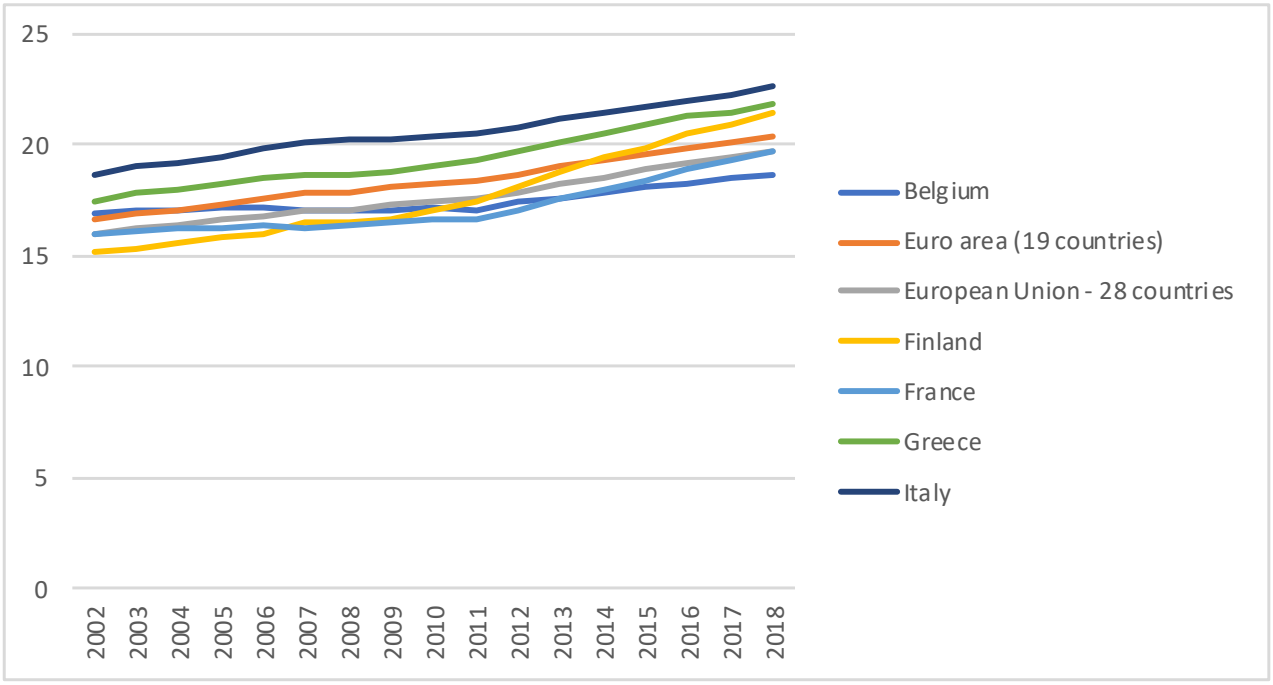


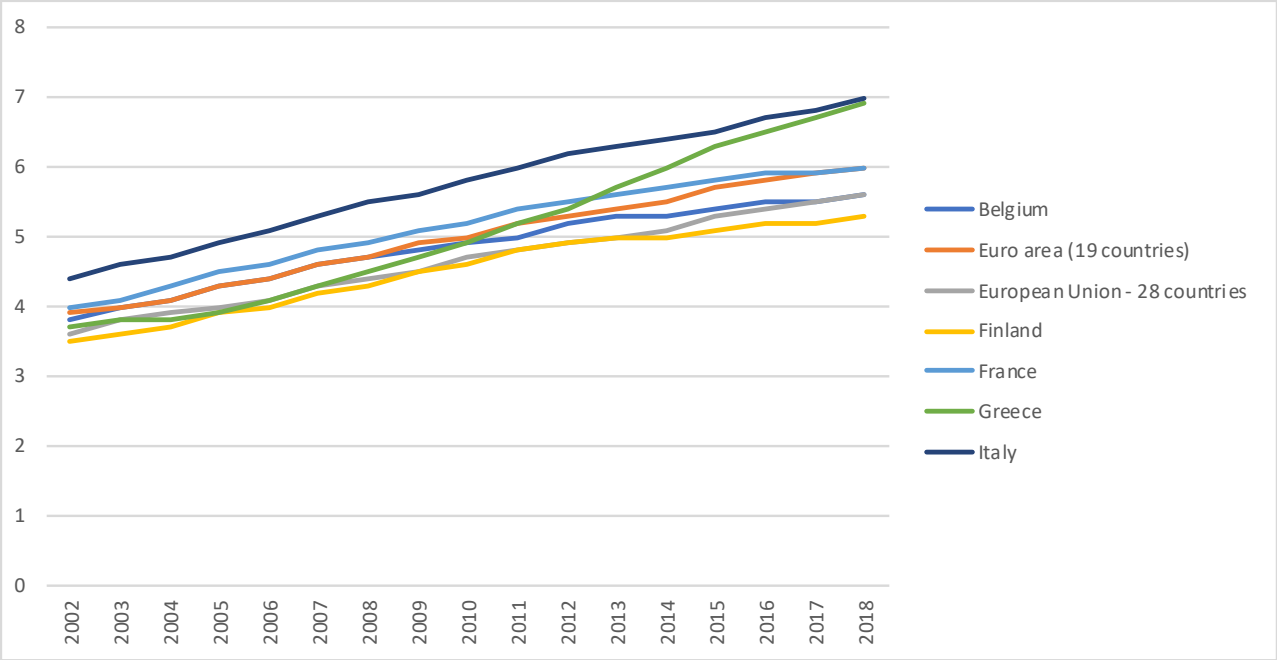
Figure 2. Population pyramids in the European Union (2003 and 2018) by sex and by 5-year age groups. Reprinted from *Population structure and ageing*, by Eurostat, 2019, retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php/Population_structure_and_ageing

Secondly, one statistic that also demonstrates well the problem is the share of population that is considered as older (65 years old or over) compared with the other age groups of the European population. Considering the whole European Union, Figure 3 shows that this share keeps on gaining ground as it reached 19.7% in 2018 in comparison with 16,7% 16 years earlier. In the same way as median age, this increase is observed in most European countries and is also more important in the Euro Area. The same observations can be made concerning the share of the population aged 80 or over which also seems to be trending upward in European countries. Figure 4 shows that it went from 4% to 6% in the EU during the same period (2002-2018). (Eurostat, 2019a)



The share of population over 65 is represented in percent (%).

Figure 3. Evolution of the share of population aged 65 or over between 2002 and 2018. Data retrieved from *the Eurostat database.*



The share of population over 80 is represented in percent (%).

Figure 4. Evolution of the share of population aged 80 or over between 2002 and 2018. Data retrieved from *the Eurostat database.*

Finally, in order to have an even better understanding of this phenomenon, we can also use another specific certain ratio, which is the old-age dependency ratio. This ratio is calculated by dividing the number of people at the retirement age and above (in this case 65 and over) by the number of people in the working ages. In this way, this ratio is used to analyse the degree of support given by the working population to the older generation. Figure 5 shows the evolution of this ratio in the European Union, the euro area and some European countries. If we have a look at the EU, in 2002, it was equal to 23.9% and has gone up to reach 30.5% 16 years later. It means that, at this day, for each person above 65, there exist hardly more than 3 working age people. (Eurostat, 2019a)

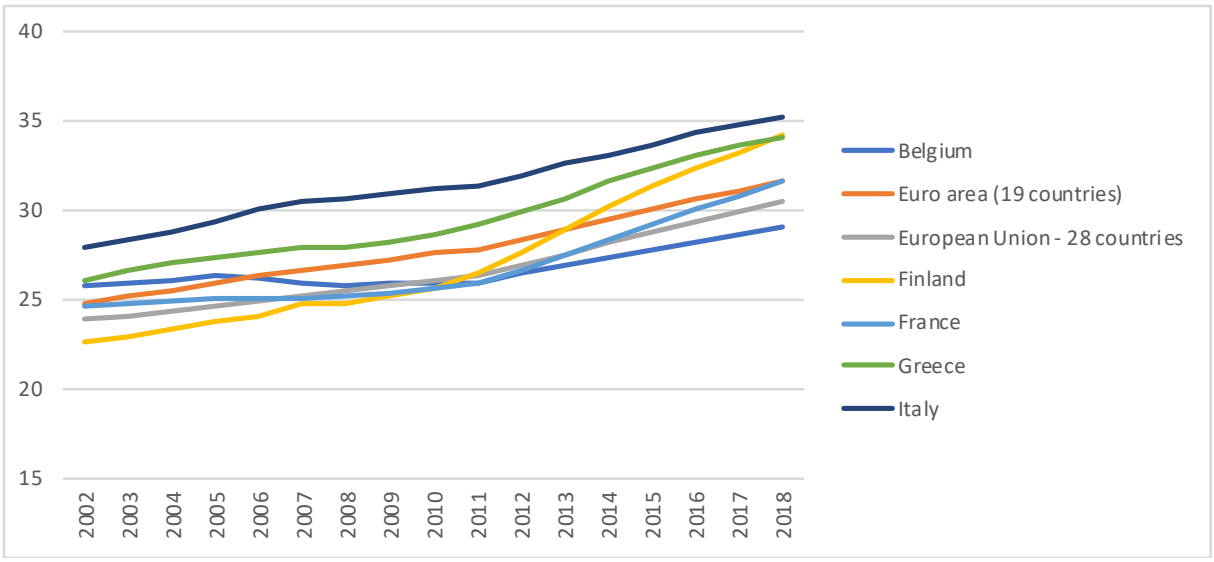


Figure 5. Evolution of the old-age dependency ratio between 2002 and 2018. Data retrieved from *the Eurostat database.*

Historical perspective

The current phenomenon of population ageing is dependent on the three demographic factors that will cause the age structure of a population to fluctuate: mortality, fertility and migration. Those three factors have all been largely impacted since the demographic transition known by Europe and the rest of the world.

Before that demographic transition, European population growth was very slowly moving. At this moment, fertility was quite high, averaging at four to five births per woman, and mortality was high too, with life expectancy between 25 and 35 years. In reality, population size was moving at the same pace as the slowly growing economy occurring at this period. (Lee, 2008)

The demographic transition first started in Northwest Europe around 1800, along with the industrialization period. During this period, mortality was the first factor to have a real impact on demographics. Indeed, it started to highly decline, mainly because of a diminution in contagious or infectious diseases followed by more efficient health possibilities. Also accompanied by an improved personal hygiene and nutrition, it has allowed European countries to achieve enormous mortality reductions up to this day. (Lee, 2008) This is represented in Figure 5, in which we can also observe that, at this day, Europe is the part of

the world with the highest life expectancy. Following the World Bank Groupe, its level in 2017 was 81 years old.

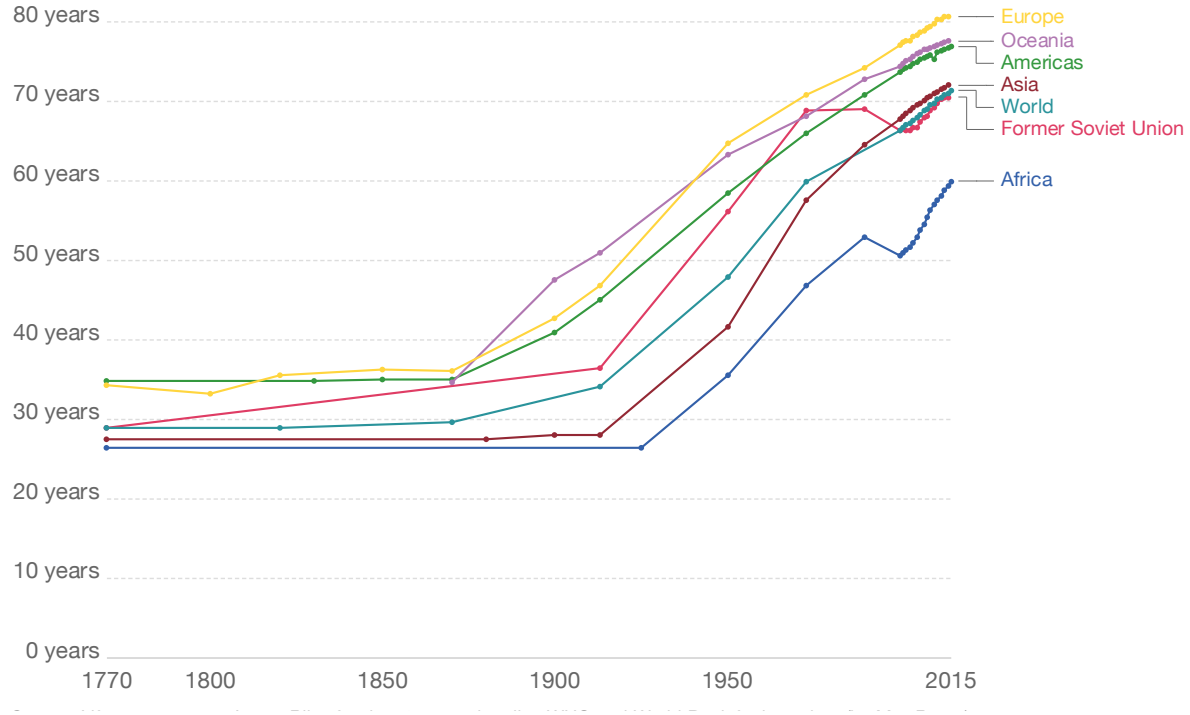


Figure 5. Life expectancy globally and by world regions since 1770. Reprinted from *Life expectancy,* by Roser, M., 2019, retrieved from https://ourworldindata.org/life-expectancy

Not too long after the beginning of this drop in mortality, fertility also started to decrease in most of the European countries around the end of the 19th century. Those two factors are actually quite related. Indeed, as mortality decreases, it influences fertility as parents do not research births per se, but well surviving children. In another way, child survival is also a response to the decision for parents to have less children in order to invest more in their health and welfare. This way, bearing children becomes more and more expensive due to a shift of resources that parents spend on their children's health and education, away from sustaining a large number of offspring. (Cervellati, Sunde & Zimmermann, 2017) On top of that, education also has an effect as educated parents see a higher value in time but children's economic contributions are also lowered due to school time. (Lee, 2008)

While fertility rate had been decreasing for decades, it started to rise again right after the end of World War II, which also marked the beginning of what is called the "baby boom" period.

Indeed, from the mid to late 1940s to the late 1960s, the dynamics of reproduction changed in most of the developed countries that participated in the war. More precisely, this period was hit with a rise of total fertility, an acceleration of marriage rates and a steep increase in the number of births.

In the beginning of the 1970s, the decline reappeared with the baby bust. This experience was totally not expected by demographers at that time. (Van Bavel & Reher, 2013)

The current ageing population phenomenon in developed countries is therefore partly due to this baby boom period as a greater proportion of this generation has now started to attain retirement age. Indeed, working people born in 1945, and who were thus the first ones to come from this baby-boom generation, reached the age of 65 in 2010. That share of people over 65 as well as the old-age dependency ratio therefore started to rise even more importantly and it is projected go on for at least 15 years. Moreover, because of the baby bust that followed, the working age population has already begun to shrink and it helped creating this ageing situation. Indeed, the decreasing fertility rate that it brought has carried on for multiple years. According to England and Azzopardi-Muscat (2017), the real struggle started in 1990 when each region of Europe had a total fertility rate below replacement level. This level corresponds, for developed countries, to 2.1 children per woman. This is considered as the total fertility rate which allows a population to exactly replace itself from one generation to the next, without taking migration into account. (Searchinger, Hanson, Waite, Harper, Leeson & Lipinski, 2013)

To be exhaustive, we must underline here that we find a small divergence between Western and Central Europe on one side and Southern and Eastern Europe on the other side. Western and Central Europe had lower fertility rates before 1990 but went through a slight decline afterwards, while Southern and Eastern Europe experienced a sharper decrease and found themselves at a lower level of fertility in 2010. (England et al., 2017)

Changes in fertility and mortality throughout time help understanding why European population growth has started to decline and why population has been ageing for some decades now. However, as said above, a third pillar has a significant impact, this one being migration. Indeed, people from different ages immigrating to or emigrating from a country or a region will cause changes in the age structure of its population. According to Santamaria,

Tintori and Vespe (2019), until the beginning of the Second World War, most of the migration happening in Europe consisted in movements within or out of the continent. Afterwards, the situation steadily reversed from this net emigration situation to net immigration as we can see on Figure 6. Several migration waves have happened between the mid-20th century and now. Most of them were inflows from North Africa and Asia to Southern Europe while others involve intra-regional movements between Southern and Eastern Europe and Northern and Western Europe. (Santamaria et al., 2019). According to the last report of Eurostat (European Statistical Office) published in 2019, approximately 22.3 million non-UE members were living in an UE Member State on 1 January 2018, representing 4.4% of the whole Union European population. On top of that, 17.6 million Europeans were living in one UE Member State with the citizenship of another one. It is also important to mention that non-UE immigrants population is younger than the national population. On 1 January 2018, the median age of foreigners immigrated in the EU was 36 years, while the median age of the national population in the EU was 44 years. (Eurostat, 2019b) We therefore notice the positive impact that immigration has on the age structure of the European Union.

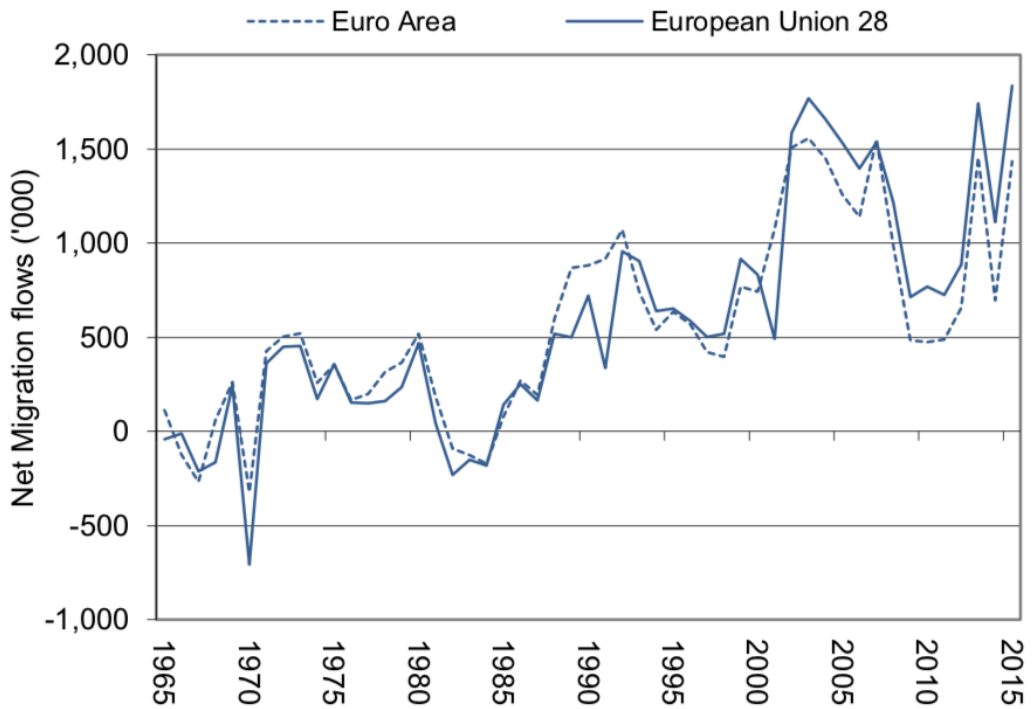


Figure 6. Net migration flows between 1965 and 2015. Reprinted from *The 2018 Ageing Report. Underlying Assumptions & Projections Methodologies*, by the European Commission, 2017, *Institutional Paper, 065,* p. 17.

1.1.2 Expectations about the future demographic situation

Numerous researches have been conducted in order to figure out what the next demographic trends in Europe will consist of.

In the same way as we did previously, we will analyse the three different demographic factors to see how the age structure is predicted to vary across European countries.

We first start with the expected upcoming mortality trends. According to the 2018 Ageing Report of the European Commission, life expectancy at birth in European countries is projected to keep on going up until at least 2070. Considering each gender, life expectancy at birth for European men is supposed to climb from 78.3 in 2016 to 86.1 in 2070. With regard to women, whose life expectancy at birth was already higher in 2016 with 83.7, the same increase is expected to happen to finally reach a life expectancy of 90.3 in 2070. Nevertheless, it seems that projections diverge depending on Member States. Indeed, life expectancy is projected to increase at a higher pace in Eastern European countries such as Estonia, Latvia, Lithuania, Hungary and Romania. Those countries had the lowest life expectancies for both men (from 69.3 to 72.8 years) and women (below 80 years) in 2016 and could consequently catch up with countries situated in other European sides.

The second demographic factor, fertility, seems to be also taking an upward path. Indeed, while the total fertility rate got steadily smaller until 2010 where it bottomed out at 1.5, it seems to be have been taking a reverse direction since that year as it has already climbed to 1.55 and is supposed to keep on increasing to finally end up at 1.8 in 2070. The same assumptions are true for the euro area, where an increase of similar magnitude is projected, from 1.56 in 2016 to 1.79 in 2070. Over this period, the total fertility rate is expected to rise in all Member States except for France which already had the highest total fertility rate (namely 2.01) in 2016. It has also been noticed that fertility rate in each of those countries are projected to still stay below the replacement level about which we have discussed above. (Ageing Report of the European Commission, 2018)

Finally, the third element that will certainly have an impact on the development of the age structure across European countries is migration. According to the 2018 Ageing Report of the

European Commission, net migration for the whole EU will be continue to be positive, which implies more inflow movements from the rest of the world than outflow movements. However, if we look at annual net inflows, they are forecast to decline from approximatively 1.5 million people in 2016, which represents 0.3% of the total European population, to 805,000 people in 2070, or 0.2% of the population. During this period of 54 years, if we cumulate each annual net migration, immigrated people will represent about 11.3% of the EU population. The same situation is supposed to happen in the euro area where inflows would keep on being positive but would also decline (from 1.1 million people in 2016 to 628,000 people in 2017). The cumulative net migration are forecast to equal 12.8% in the area.

Even if projections diverge between the Member States, some trends can be identified. First of all, some Eastern European countries (including Bulgaria, Latvia, Lithuania and Romania) which faced net migration outflows on average in this last decade are projected to have overcome or even reversed those outflows by 2070. If cumulated, the migration flows would however still be negative. Secondly, a few countries that were impacted by the crisis and thus for whom net migration went negative in 2015 (namely Spain, Portugal, Cyprus and Ireland) should observe a comeback in the following years. Concerning Greece and Croatia which was impacted the same way, they are expected to take a bit longer for net inflows to return. (European Commission, 2018)

Against this backdrop, the European Commission has predicted a real change in the age pyramidal of the EU population, which will get older and older. As we can see in Figure 7 comparing the age structure between 2018 and 2100 in the EU, projections show that the share of the population over 85 years is expected to skyrocket over the years to finally become the most important one for both men and women.

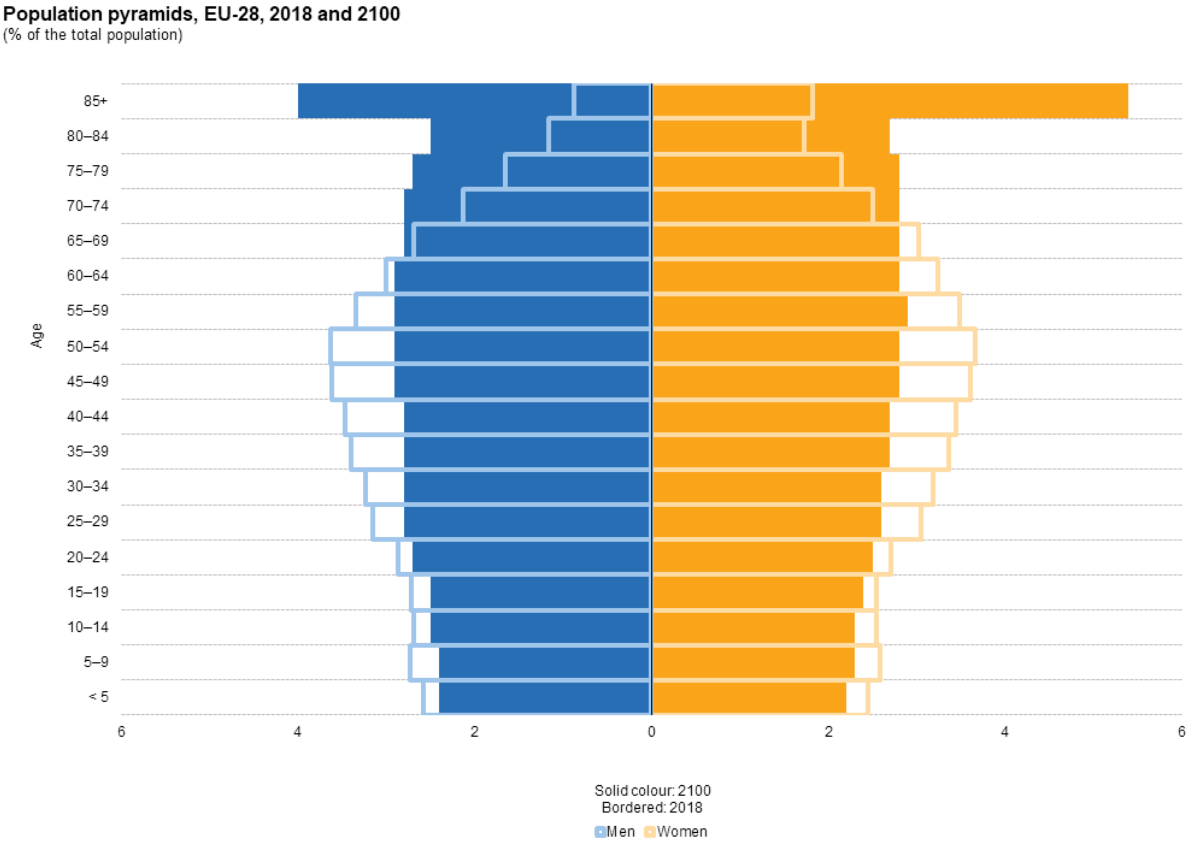


Figure 7. Actual (2018) and projected (2100) population pyramids in the European Union by sex and by 5-year age groups. Reprinted from *Population structure and ageing*, by Eurostat, 2019, retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php/Population_structure_and_ageing

In order to understand that, we can observe the evolution of the old-age dependency ratio. This one is predicted to almost double from 2015 to 2070. At this moment, the projections estimate that it will have reached 54.2%, which is 25% more than 55 years before. In 2070 and among all large countries, it will be the second highest ratio before Japan with 69.6%. The same trend can be observed as we look at another dependency ratio, the very-old-age dependency ratio. This ratio calculates the number of people over 80 to the working population. While it only reached 7% in 2015, it is projected to attain 21.5% in 2070. Another clue is the shift in the median age across Europe, which is supposed to rise from 42.4 years old in 2015 to 46.7 years old in 2070.

Therefore, all of those hints confirm the hypothesis that population in Europe, as well as in the whole world, will significantly age as we get closer to the 22nd century.

Chapter II : The secular stagnation concept as economic context

After this presentation of some relevant figures about the population ageing phenomenon, we cannot fail to mention the secular stagnation concept, a major economic thesis which considers population ageing as an important factor of the economic evolution in developed countries.

In this chapter, we will first of all discuss the origin of the concept in the 1930s as well as different definitions found in the literature in order to explain what the secular stagnation consists of. Afterwards, we will explain how this concept has recently become popular again, especially in the aftermath of the financial crisis of 2007. As this matter is quite complex, we will only consider some fundamental aspects. In order to do so, we will use two different explanations found by different economists: one using the demand side and the other one using the supply side. Finally, we will detail the findings of several authors who have demonstrated that population ageing, which Europe is facing at the moment, is partly responsible for this secular stagnation phenomenon.

1.2.1 Definition

The secular stagnation concept was first introduced by the American economist Alvin Hansen who is considered as the pioneer of this expression. In his American Economic Association presidential address “Economic progress and declining population” (1939), he resumes the economic struggles encountered in the 1930s, seen as consequences of the Great Depression. According to Hansen, those can be seen as evidence of a “secular stagnation” situation caused by multiple factors: the closing of old economic frontiers, the technological slowdown and most importantly a radical decline in population growth. He explains his fear that this demographic downshift would decrease the possibilities to invest successfully and, in the same time, increase levels of saving. That would be accompanied by a long period of low-growth equilibrium where unemployment is largely spread and resources underutilized, but

also where a discrepancy exists between actual income and potential GDP which would cause a deflationary gap.

Some other researches were made in the 1940s and added contribution to this subject. In 1943, Pigou analysed the secular stagnation issue by being the first to formulate it as an equilibrium for which the real interest rate that stabilizes savings and investment at full employment is negative. This postulate was new as, until then, economists usually admitted that a balanced interest rate could not go into negative territory. They used this impossibility for market rates to go negative to explain the complexity to get back from a prolonged stagnant economic situation, especially if it is accompanied by low inflation. This new contribution has been important until now as many modern theories concerning secular stagnation rely on the implication of negative natural interest rates [1] at the steady macroeconomic equilibrium. (Dufrénot & Rhouzlane, 2018)

As a result of the baby-boom and the technological progress in the 1950s and 1960s, Hansen's theory was not verified and economy bloomed for several decades. (Probst, 2019)

Nevertheless, the concept has come back and has been "re-popularized" in the aftermath of the 2007 financial crisis. Indeed, a recent review of secular stagnation was made by Lawrence H. Summers in his speech at the International Monetary Fund headquarters in November 2013, during which he used the secular stagnation theory suggesting that it is "*the defining macroeconomic challenge of our times*" (Summers, 2013). He mentioned this phenomenon when referring to the surprising fall of US GDP behind its potential, even with the help of financial and monetary policy interventions. He also pointed out that some of the factors that caused the emergence of the secular stagnation concept in the 1930s re-emerged. Indeed, developed countries are ageing as birth rates are declining and life expectancy is increasing. Nevertheless, a baby-boom period is not likely to show up as it did after WWII. Besides that, employment did not increase significantly, capacity utilization wasn't under pressure and inflation remained quite low. (Cervellati et al., 2017)

[1] The natural interest rate is "the rate that would keep the economy operating at full employment and stable inflation". (Wessel & Olson, 2015)

Summers (2013) also argued that, as the short-term real interest rate that is consistent with full employment was suspected to have dropped to zero or even below, it may be impossible to use the traditional monetary policies, such as a decrease in interest rates, to stimulate investments and consumer spending.

1.2.2 The economic mechanism behind secular stagnation

The current economic slump that developed countries, and therefore Europe, have been facing, particularly in the aftermath of the financial crisis of 2007, can be characterized by changes in different economic factors. The secular stagnation concept has been developed by economists under several dimensions which have helped to find an explanation about the current economic factors movements. In this section, we will then describe the different factors according to those dimensions and the reasons why it is difficult to reverse the situation.

Demand-side explanations

Savings and investment

One of the dimensions which was first mentioned and mainly developed by the American economist Alvin Hensen in 1939, is the demand-side thesis. In his paper, he stated that the combination between a persistent excess of savings and, on the other side, investment that keeps on getting lower will tend to drive the equilibrium interest rate into negative value. That will therefore lead to a weaker demand and thus lower growth.

There are several reasons that explain how we have arrived at this situation of excess savings and low investment. As mentioned by Eggertsson and Krugman in 2012, it finds its roots in a slump of the financial cycle which forces the agents into rapid deleveraging. The two authors also argue that this phenomenon is then depressing aggregate demand and may cause a liquidity trap. In order to understand that, it is helpful to have a look at the Over-Lapping Generations model that they developed to represent the phenomenon. As we can see in Figure 8, the economic cycle of households is divided into three periods: young, middle-aged

and old. Income is mostly concentrated within the middle-aged stage. During the first period, young people do not have enough liquidity and the demand for borrowing increases. Besides that, middle-aged have incentives to save their income by lending it to the young, as it is assumed that borrowings by young people are limited by a credit limit. In this environment, the real interest rate depends on the supply of savings and on the demand for loans, meaning that the equilibrium real interest rate could easily become negative and stay in that way permanently. This has been the case in many developed countries these days mainly because of three forces. The first two ones are the slowdown of population growth, which results in a higher supply of savings, coupled with a tighter debt limit, which decreases demand for loans. The last factor is an increase in income inequality which could also push the real interest down. (Eggertsson et al., 2012)

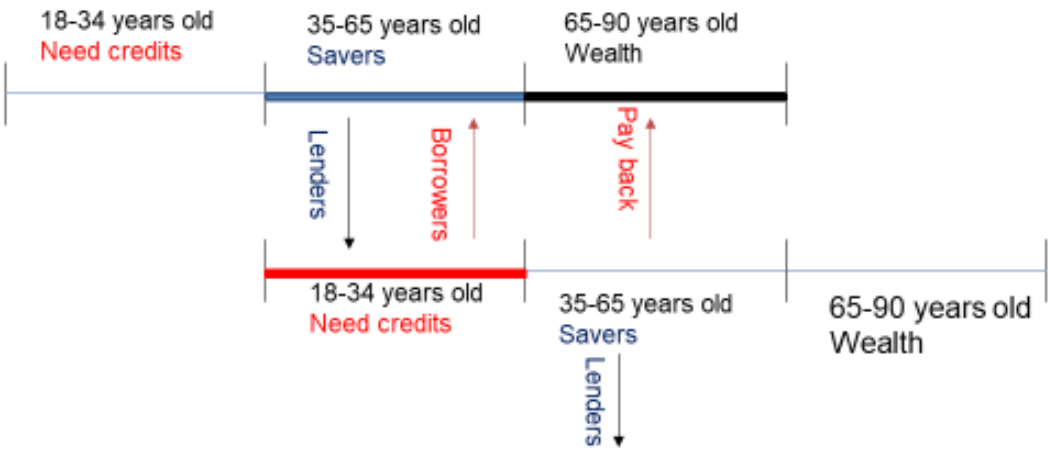


Figure 8. Representation of a three period OLG model with loans and credits. Reprinted from *Secular Stagnation: New Challenges for the Industrialized Countries in the 21st Century*, by Dufrénot, G. and Rhouzlane, M., 2018, *AMSE: Working Papers, 18,* p. 11.

A couple of other authors found further causes explaining this tendency. According to Caballero, Farhi and Gourinchas (2016), the fact that we find ourselves in secular stagnation comes from imbalances which are mainly due to the scarcity of safe assets, also named non-risky assets. Indeed, while the demand in safe assets to invest in is growing steadily, the supply has not been able to keep pace. The reason why demand reaches a higher level is mainly because of economic uncertainty and expectations of deflation which leads agents to a

stronger aversion to risk and therefore to a preference for safety. Concerning the supply side, its decrease in manly due to the Eurozone crisis which has led to some government debt losing its "safe asset" status. (Landau, 2014) In their paper, Caballero and Farhi (2014) demonstrated that the supply of safe assets dropped from 37% of the world GDP in 2007 to 18% in 2011. This whole mechanism pushes down the real interest rate. The system equilibrates as long as central banks manage to lower nominal interest rates and therefore accommodate this downward pressure. However, this adjustment is not feasible if nominal interest rates hit the Zero Lower Bound[2]. (Caballero & Farhi, 2014)

Some other elements have been added in the literature by Summers (2014) who explains the reasons why the investment demand is reducing and how the supply of savings keeps on increasing.

We will first look through the factors impacting the investment demand. Firstly, a decline in the price of capital goods has been observed during these past years, which means that investment goods can be realized without having to spend or borrow too much. That further leads to a reducing propensity for investment. Secondly, another factor is the changing nature of productive economic activity. We are in a period where the leading companies are mainly technology companies, such as Apple or Google, and those are having trouble to deal with their excess of cash. Indeed, they do not require a large quantity of capital investment to achieve their goals. It takes much less money to start a new venture today compared to the past. All of that means that demand for investment is reduced.

Summers (2014) also developed an argument for the increasing propensity to save, which is changes in the distribution of income. Due to more inequality in income distribution, richer households will have a higher propensity to save than less-wealthy households. That would lead to an increase in aggregate saving. However, this vision can be criticized. Indeed, several studies have found that, as a response to the rising top incomes, middle- and low-income earners will tend to lower their saving rate. (Drechsel-Grau & Schmid, 2014; Bertrand & Morse, 2016)

[2] The Zero Lower Bound is the lower limit that nominal interest rates can be cut to. Further explanation will be given later in this section.

Interest rates

The decline of interest rates is seen as one of the main elements of the secular stagnation theory. Indeed, as Ferrero et al. (2017) noticed, there has been a decline in long- and short-term nominal rates since the mid-1980s. Figure 9 shows the interest rates movements for some European countries as well as Japan and the US.

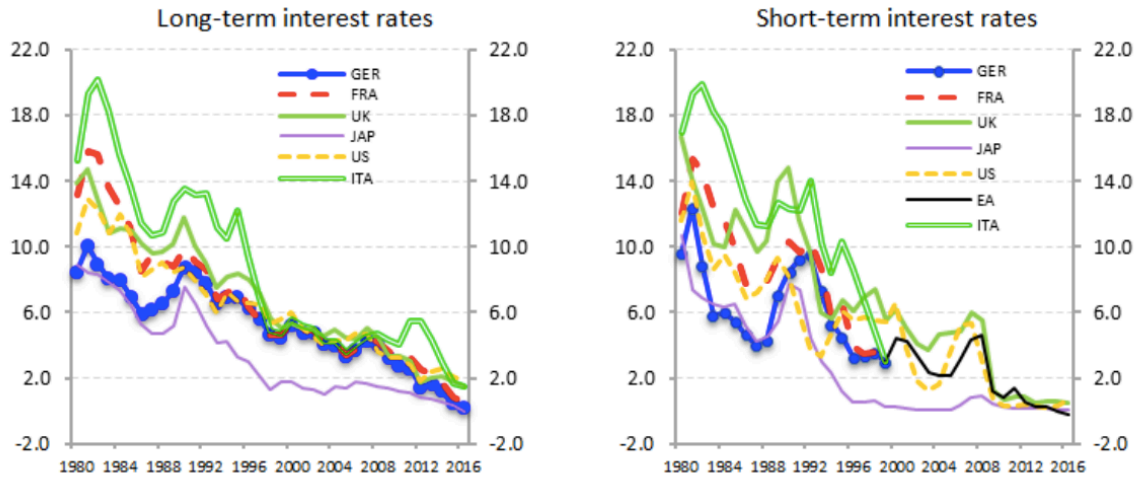


Figure 9. Long-term and short-term interest rates from 1980 to 2016 in developed economies. Reprinted from *On secular stagnation and low interest rates: demography* matters, by Ferrero, G., Gross, M., and Neri, S., 2017, *ECB : Working Paper Series, 2088,* p. 5.

This situation has been the subject of many researches and is part of this demand-side thesis as confirmed in 2015 by the economist H. Summers who is one of the defender of Hensen's theory. In order to defend his ideas, he inspired himself with Pigou's postulate in order to represent the secular stagnation situation through the existence of a negative natural interest rate. According to him, a real struggle comes by the fact that, as the nominal interest rates[3] in the US and in Europe are constrained at the zero-lower bound, real interest rates cannot experience another fall in order to stimulate investment and therefore be compatible with full employment. Indeed, it is the role of central banks to manipulate interest rates in order to stimulate an economy that is stagnating or in contrary temper an economy that is functioning too strongly. Nevertheless, there are limits to which central banks can effectively control

[3] The nominal interest rates corresponds to the interest rate before inflation is taken into account.

interest rates, especially at the lower end. This limit is called the Zero Lower Bound (ZLB) and is the reason why the recession we are facing is not only a temporary fluctuation. Summers (2015) sees the ZLB as a natural market imperfection. This bound prevents economic actors to settle nominal interest rates at a lower level than zero. It implies that other interest rates which take into accounts term and risk premia are also bound.

Today, it sometimes happens that nominal negative rates are applied, as it is the case today for example in Switzerland with a rate of -0.75%. This situation has become more frequent since the global financial crisis of 2007-2008. If this level is reached at any time and the economy is still not performing, the central bank is no longer able to create stimulus through interest rates and thus the economy finds itself in what is called a liquidity trap. Some alternative monetary policies are then needed to stimulate the economy. (Mitchell, 2019)

Inflation

As it has already been said, secular stagnation is also characterized by a particularly low inflation. Indeed, Europe as well as other developed economies such as the Unites States have been facing a period of disinflation. Figure 10 shows the evolution of inflation rate in the euro area as reflected by the Harmonized Index of Consumer Prices from 2007 to 2018. It appears that there have been different periods during which inflation rate shifted in opposite directions. First of all, while it was approximately equal to the target rate of 2% established by the ECB in 2007, inflation rate reached a much higher level in 2008. It is substantially explained by the sharp increase in raw materials prices. In 2009, inflation dropped with the recession caused by the global financial crisis and the collapse of raw materials prices. By injecting liquidity into the system, the ECB and national governments managed to have the inflation recover and even reaching target in 2011. This tendency did not last long as it decreased sharply the following year. Once again, it is mainly due to the fall of raw materials prices, accompanied by the increased euro exchange rate, a rising unemployment rate and a weaker demand. (Fontan, 2014a)(Fontan, 2014b)

In 2016, inflation rate bounced back and it has been increasing since then to finally almost reach the ECB target rate in 2018. This is also due to an increase of energy prices and food prices coupled with ECB monetary decisions. In the 2018 Annual Report of the European Central Bank, its president, Mario Draghi, even showed confidence in a sustained upward

trend of inflation and in the achievement of the objective in the medium-term. (2018 ECB Annual Report)

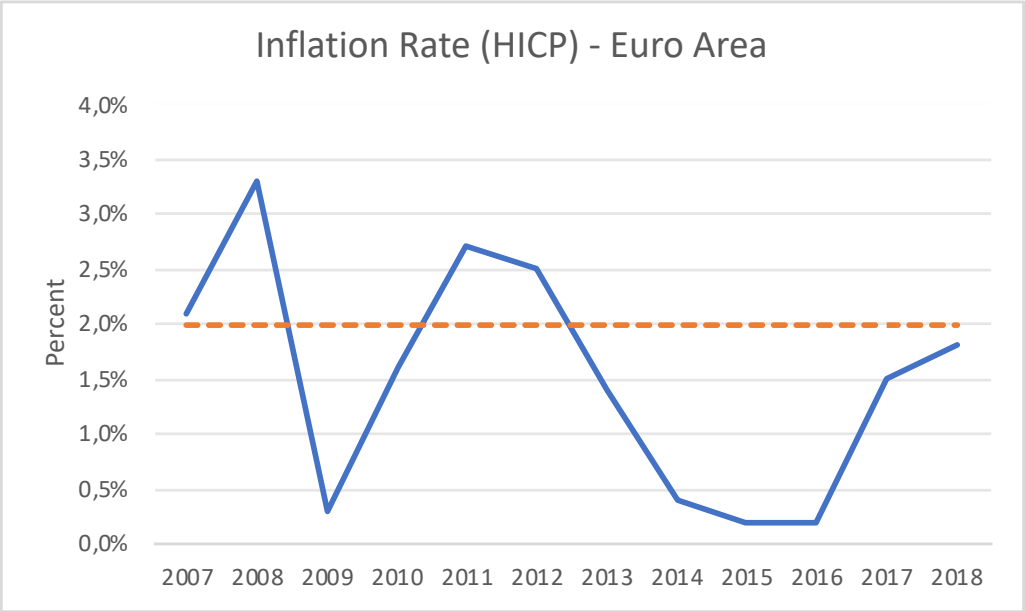


Figure 10. Evolution of the inflation rate in the euro area between 2007 and 2018. Data retrieved from *the Eurostat database*

Output

As it is impossible for long-term rates to get lower than the Zero-Lower Bound, and if the economy is still underperforming, the output will be impacted instead of those interest rates. Indeed, Summers, Eggertsson and Mehrota (2016) proposed a model where it is assumed that investment is a decreasing function of the interest rate while saving is an increasing function of the interest rate. In this model, the level where equilibrium is consistent with full employment requires a nominal interest rate below zero. Because of the ZLB and thus the inability for central banks to decrease interest rate even more, adjustments will then happen in the form of a lower level of output which will continue to decline indefinitely. (Summers, 2015)

We will use the Gross Domestic Product (GDP) as the indicator of the evolution of output in Europe. Figure 11 shows the levels of both actual and potential[4] output in the euro area where actual output is real GDP and potential output is based on European Commission estimates. The linear projection represents the path implied by the pre-crisis situation. As it can be observed, the current estimates are well below what could have happened if potential output steadily increased at the same pace as recorded in 2007, before the crisis. Those were indeed revised downwards right after the onset of the global financial crisis, while still continuing to increase. The last estimate of the European Commission was made in 2017 and was approximately 10% below the level of the linear projection. Concerning real GDP, it was also naturally impacted by the financial crisis in a strong way and declined abruptly. Therefore, a negative output gap appeared after the eruption of the global crisis. However, as real GDP seems to have bounced back during these last years, this output gap is getting less and less important and appeared to be even close to zero. (Andersson, Szörfi, Tóth & Zorell, 2018)

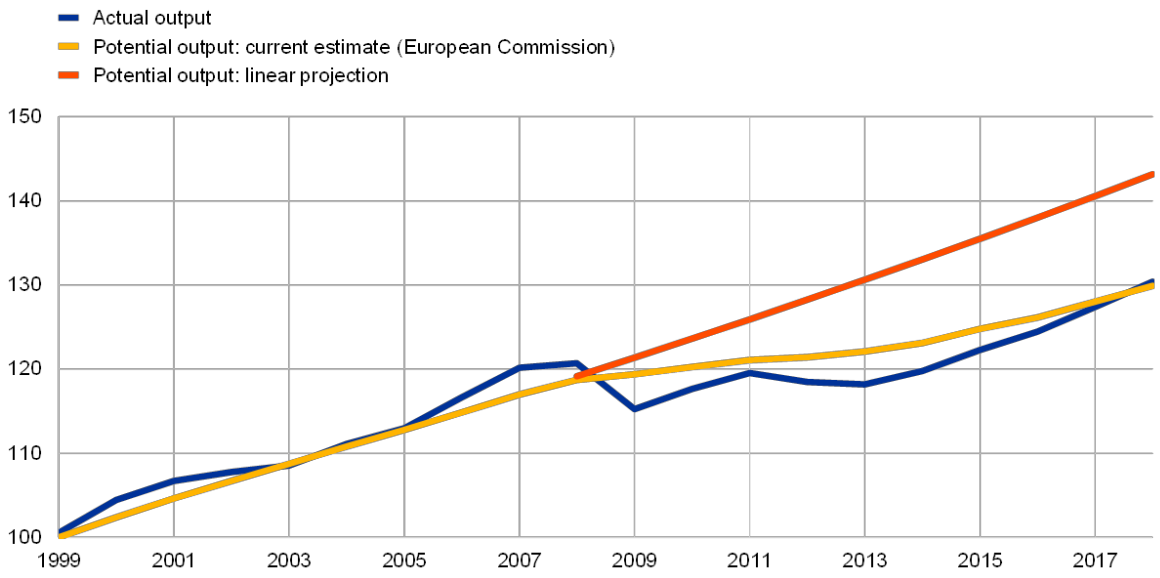


Figure 11. Evolution of actual and potential output in the euro are between 1999 and 2018. Reprinted from *Potential output in the post-crisis period,* by Anderson, M., Szörfi, B., Tóth, M. & Zorell, N., 2018, *ECB Economic Bulletin, 7,* p. 54.

[4] Potential gross domestic product (GDP) is defined in the OECD's Economic Outlook publication as the level of output that an economy can produce at a constant inflation rate.
Source: Eurostat (2001) Retrieved from https://stats.oecd.org/glossary/detail.asp?ID=2094

Supply-side explanations

Some authors, such as Gordon (2012) and others, have another thinking about the reason behind the slow growth that European countries are facing. Indeed, according to Roeger (2014), potential growth has declined strongly in the euro area, from about 2.0% over the 1999-2008 period to an average of 0.5% in the after-crisis period (from 2009 to 2014). What differs from previous authors is that Gordon and other economists question the fact that the current reduced growth is a demand-side problem as argued before or, on the contrary, a supply-side issue.

Gordon (2015) identifies the reasons behind this lower potential growth. He found that it is partly due to a deceleration in the rate of technological progression over time as well as what he called four "structural headwinds". Two of them are actually also part of the demand-side arguments. Those are the rise in income inequality but also the expected ageing of the population. The two others are the fact that the average educational attainment levels are getting lower and the unsustainability of public finances due to high public debt levels.

Nevertheless, this supply-side theory was criticized by Larry Summers (2015), who argues that a supply shock is normally characterized by quantity going down but prices going up, which is not the case here as inflation rates have been declining, what therefore suggests more the importance of demand. He suggests that there are enough considerable reasons that show the consequences of demand shortfalls for economic potential because of the reduction of investment in all kinds of capital. He also believes that, even if potential growth declined substantially because of supply-based causes, the ZLB will be a real problem for the economic activities and that makes demand-side secular stagnation a crucial matter.

1.2.3 Population ageing matters

As we have seen, the actual economic slowdown represented by this secular stagnation hypothesis is caused by several different elements. One of those elements, as Hansen (1939) already put down in the 1930s, is the impact of the demographic trends. As it has been said in the first chapter, there are currently shifts in the pyramidal structure of European countries

resulting in an older population and that is planned to affect the economic stability of those countries by exerting downward pressure on some components of potential growth. (Nerlich & Schortch, 2018) This section will therefore describe the reasons behind that idea.

Firstly, as previously said, a consequence of population ageing is a higher old-age dependency ratio, meaning that the ratio of workers to pensioners decreases. Following the scenario tested by the European Central Bank (ECB) in one of its report concerning the ageing population, this should have a negative impact on labour supply and employment as fewer people find themselves in the labour market. Moreover, there exist divergences of participation rates between the different age cohorts in the euro area. Regarding "prime-agers" (considered as people between 25 and 54), their participation rate in 2016 was around 85% while younger people (under 25) and older people (between 55 and 64) seem to have lower ones (respectively 40% and 60%). The struggle comes from the fact that "prime-agers" cohorts are projected to become older people over the next few years while only small cohorts are expected to become in turn prime-agers. Therefore, in case there is no change in participation rates across ages, downward pressure will be applied on the labour supply.

Secondly, the population ageing phenomenon has negative effects on output per worker. That is the results of several researches (Nagarajan, Teixeira & Silva, 2013; Maestas, Mullen & Powell, 2016) which studied the effects of ageing workforce on aggregate labour productivity. These effects occur in a weaker growth of what is called total factor productivity (TFP). TFP is actually a measure of productivity growth which is derived from more efficient production processes and technological progress. This phenomenon was studied by Aiyar and Ebeke in 2016, who also found out that ageing reduces growth in labour productivity and they estimated that TFP growth would be reduced by approximately 0.2 percentage points each year for the following twenty years in European countries. The main reason behind this declining productivity could be the fact that a worker's productivity varies during his working life. Usually, a typical worker is represented by a strong increase in productivity until his 40s followed by a decline toward the end of his working life. The causes of this decreasing productivity across generations are the lack of new technology skills and willingness to learn, combined with less stamina, creativity and flexibility as well as a higher probability of health issues. Some authors (Maestas et al., 2016) also found out that slower growth in productivity across generations and slower labour force growth due to ageing leads to a decrease in GDP

per capita. Taking the example of the United States, they found that a 10% increase in the share of elders (60+) reduce the growth rate of GDP per capita by 5.5%.

Nevertheless, there may exist counterbalancing factors that could help mitigating these negative effects on productivity. For example, the return on investment in human capital might be increased thanks to the labour scarcity, meaning that workers have more incentive to follow training during their working life. That is even more efficient if the retirement age is also increased. Another force could be that low fertility rates should allow to invest more in human capital for each child. Finally, a positive effect of ageing workers are that they have accumulated experience and expertise throughout their working lives. Therefore, as workers shift towards sectors which demand knowledge and where productivity levels can stay constant through workers' lives, that might limit the negative impact that ageing labour has on productivity. (Nerlich et al., 2018)

Another consequence of population ageing is the rising of age-related public spending. According to the European Commission's 2015 Ageing Report, public expenditures that will be carried out on pensions, health care and long-term care are projected to rise from 21% of GDP in 2013 to 23% of GDP in 2060. Besides the rising of these costs, a fall in public revenues is also expected for several reasons. First of all, private consumption among workers decreases as they prefer to go for precautionary savings, making the revenue of VAT plunge. Secondly, it has been proved by Lührmann (2005) that elderly tend to spend more on services (such as housing and healthcare) than goods. However, some of these services benefit from tax exemptions in several European countries, which means that ageing would imply revenue from VAT to fall even further down. The last reason explaining decreasing public revenues is weaker revenues from personal income tax due to a drop of workers in the labour force, tax rates remaining unchanged. Overall, as public spending is expected to rise while public revenues, on the other hand, should fall because of all the reasons explained above, the public debt will then also suffer the consequences by a significant increase. Thus, in the end, the ageing population in Europe in this scenario is supposed to result in a government debt-to-GDP ratio that explodes. (Nerlich et al., 2018)

On top of that, demographic factors reflecting population ageing are also responsible for changes in the way agents decide to save or invest. As we have seen in the previous chapter,

the way that people decide between savings and investment is really important as the equilibrium between those will impact the real interest rate. It is then interesting to observe if ageing will impact the savings and investment behaviour of agents in a way that supports or on the contrary mitigate the secular stagnation hypothesis.

In order to understand an agent's behaviour during his different life stages, it is interesting to use the *life-cycle hypothesis*, developed by Modigliani and Brumberg (1954), which provides a direct theoretical relationship between ageing and saving behaviour. As we can see in Figure 12, the theory implies that older people, who are approaching the end of their lives, and younger people, who are still educating themselves and do not necessarily earn any sort of income, save less then middle-aged individuals. (Boersch-Supan & Winter, 2001) Therefore, if we rely on this model, a negative relationship should exist between household saving rate and the old-age dependency ratio as demonstrated by Loayza, Schmidt-Hebbel and Servén (2000). That would therefore lead in higher interest rates.

Figure 12. Age-saving profile implied by the life-cycle hypothesis. Reprinted from *From Red To Grey,* by Chawla, M., Betcherman, G. and Banerji, A., 2007, Washington D.C.: The World Bank, p.120.

Nevertheless, the empirical validity of the model is still a topic of debate. Some studies show that savings do increase between youth and middle-age, but they do not necessarily support the fact that individuals reduce their savings toward the end of their lives. It is notably the case of Germany as discovered by Börsch-Supan, Reil-Held, Rodepeter, Schnabel and Winter (2000). Germans seem to never stop saving, even after retirement. There are several reasons

behind that. For instance, it could be precautionary savings for late-life events, such as health care. (Börsch-Supan & Winter, 2001) Indeed, in the first section, we have seen that life expectancy is projected to increase over time, notably due to improvements in public health, nutrition and medicine. Therefore, instead of increasing their consumption, workers tend to increase their precautionary savings in order to harmonize their consumption across their retirement years. That means that those workers tend to be more patient before starting to consume and they are inclined to dissave more gradually in order to be certain to dispose of sufficient liquidity for their old days where consumption gets even more significant. This mechanism has a downward impact on real interest rates. (Papetti, 2019) Another argument against the life-cycle hypothesis is the possibility that individuals might also not stop saving in order to foresee a more generous legacy (intergenerational transfer).

Finally, concerning inflation and the impact that ageing has on this one, there is no theoretical consensus about whether those are positively or negatively related. Some empirical studies were conducted but they ended up with different results. On one side, some authors have focused on ageing being a possible agent of disinflation. For example, Anderson, Botman and Hunt (2014) found out that, by using the case of Japan, ageing may reduce inflation. Bobeica el al. (2017), who also studied the impact of demographics on the Japan economy, show that ageing could even lead to deflation, which corresponds to a negative inflation. Yoon, Kim and Lee (2014) focused on 30 OECD countries and they discovered that a rise in share of elders (65+) is associated with low inflation in these countries. However, another research (Juselius & Takats, 2015) demonstrated, by using a finer division of age cohorts, that the young and younger old (between 65 and 80 years old) groups are inflationary while middle-agers are disinflationary and the very old group (80+) deflationary.

Section II: Empirical research

Chapter I : Data and methodology

As a reminder, the purpose of this study is to estimate the impact of different demographic variables, reflecting the European population ageing phenomenon, on economic factors. In this section, we will first of all present the selected variables to test and the data the we collected in order to conduct this empirical research. Afterwards, we will focus on the question about which method is the most suitable in order to estimate the four different models.

2.1.1 Data

In order to conduct our test, we had to choose which variables would be needed in order to have the most interesting results. In order to select those, we based ourselves on our assumptions from the previous section and thus also on former researches which treated the same subject.

Firstly, we had to choose the dependent variables we wished to test. Our first dependent variable was the household saving rate, following the examples of Callen and Thimann (1997) and Loayza et al. (2000). Our second choice was to study the GDP per capita, as Peterson (2017), Yoon et al. (2014) and Maestas et al. (2016) did. Afterwards, we focused on the impact of demographics on the public debt, here represented as the debt-to-GDP ratio. This inspiration came from the work of Jackson, Clemens and Palacios (2017). Finally, our last model concerned the impact on inflation, in line with the researches of Yoon et al. (2014), Botman et al. (2014) and Anderson et al. (2014).

Secondly, it was also important to decide which independent variables, linked with demographics, we were wanting to use. The most commonly used demographic factor in literature to represent ageing is the old-age dependency rate. (Callen et al. (1997), Loayza et al. (2000), Hondroyiannis & Papapetrou, 1999, etc.) Besides that, many studies such as the

one made by Yoon et al. (2014) interested themselves in population growth, share of old people and life expectancy while studying the effects of demographics on economic growth. Therefore, we decided to add those variables to our models. An overview of the selected variables, as well as their definitions, can be seen in Table 1[5].

Variables	**Definition**
Dependent	
Household saving rate	Total amount of net saving as a percentage of net household disposable income
GDP per capita growth rate	Annual percentage growth rate of GDP per capita (gross domestic product divided by midyear population) based on constant local currency
Debt-to-GDP ratio	General government gross debt as a percentage of the gross domestic product
Inflation	Measured by the consumer price index which is the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services
Independent	
Old-age dependency ratio	Ratio between the number of persons of an age when they are conventionally considered economically inactive (aged 65 years old and over) and the number of persons conventionally considered of working age (respectively aged 15-64)).
Life expectancy	Mean number of years that a new-born child can expect to live if subjected throughout the rest of his or her life to the current mortality conditions
Population growth	Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage
Share of “old” people (65+)	Number of people aged 65 or over compared to the whole population
Share of “older” people (80+)	Number of people aged 65 or over compared to the whole population

Table 1. Selected variables and their definitions

[5] The sources can be found in Appendix A.

In order to estimate the impact of our demographic variables on those four economic factors, we decided to collect national data on a yearly manner. The different sources are the Eurostat database, the World Bank database and the OECD database (see appendix A for more precision).

As said earlier, we decided to conduct this research only within the European limits. In order for the study to be more convenient, we decided to use data from countries within the euro area, as they are part of a same monetary union and therefore follow a same monetary policy dictated by the European Central Bank. As a reminder, the euro area is currently composed of Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia and Spain. However, due to the fact that data coming from some of these countries (mainly old Soviet bloc countries) are often too recent and only collected on a yearly manner, we had no choice but to select the ones which allowed us to maximize the studied period. Therefore, we finally selected nine countries, which are Austria, Belgium, Finland, Germany, Ireland, Italy, Netherlands, Portugal and Spain. The observations from these countries are available between 1981 and 2017, which will be our base period.

There is however one exception, which stands for the model testing the impact of demographics on the household saving rate. Indeed, the only available source of information about this rate was the OECD database, which only contains data about six of our nine countries: Austria, Belgium, Finland, Italy, the Netherlands and Spain. The studied period still remains the same.

2.1.2 Methodology

One manner to study economic variables is to focus on one particular country. Many empirical researches have been made using simple times series data from a country to estimate the impact of demographic changes on the economic growth, e.g. Miles (1999) for the United Kingdom, Maestas et al. (2016) for the United States, etc. The advantage of only analysing data for one country is that social and political factors can be included. That allows to add useful information and to end up with more relevant results.

However, the main drawback of this type of analysis is the lack of reliable data existing for a long period of time. Statistics concerning individual countries are limited. While the economic situation of a country is quite variable across time, changes in its demographic structure are more of a slow-moving process which takes time to create observable effects. Therefore, analysing short periods of time can be an issue as the small amounts of data available for those periods might not be able to capture all the movements needed for our study. Those issues could lead to insignificant results if we only focus in a single country time-series regression.

A solution would then to use a panel data, which is composed of data from several countries. We talk about a panel data when there are two dimensions involved: a cross-sectional dimension and a time-series dimension. This allows to increase the variation in the different variables as those change more between countries than within. By adding other countries, where slow-moving variables have different values, it is more likely to be able to capture the influence of those on economic variables in a more reliable way. (Hsiao, 2007)

There exist several approaches to analyse panel data information. The easiest one is to use a *pooled ordinary least squares (OLS)* regression. This method consists of pooling all the observations and treating them in an equal manner with no assumption on individual differences.

The pooled ordinary least squares model $y_{it} = \alpha + \beta_1 x_{1_{it}} + \cdots + \beta_k x_{k_{it}} + u_{it}$ [6]

In this case, the estimator ignores the panel structure of the data. The issue is that the pooled OLS estimator will be unbiased and consistent only if observations are serially uncorrelated and homoscedastic[7]. (Mućk, 2018) However, as our panel data includes several countries with fundamental differences between them, those differences will undoubtedly bias the errors term as the models will ignore the country-specific effects. Therefore, homoscedasticity should not be assumed. We will still perform a test to be certain that a pooled OLS regression

[6] Where : y_{it} is the dependent variable; $x_{k_{it}}$ are the k-th independent variables; u_{it} is the error term; α is the intercept; β_1, …, β_k are the structural parameters; i = 1,…,n; t = 1,…,T.

[7] Homoscedasticity means that the variance of the residual, or the error term, is constant.

is not a possible option for our three models. In order to test whether country-specific or time effects are present in the residuals of these regression, we can perform the Breusch-Pagan test. (Breusch & Pagan, 1980) The null hypothesis for this test is homoscedasticity, and this one is rejected for our three models as it can be seen in Table 2. Therefore, a pooled OLS model cannot be used in our empirical research as it will not be consistent.

Models (dependent variable tested)	**p-value**
GDP per capita growth rate	0.0007923
Household saving rate	3.523e-08
Debt-to-GDP ratio	7.397e-08
Inflation	7.395e-13

Table 2. Results of the Breusch-Pagan test

In order to capture the country-specific effects resulting in individual heterogeneity, a model named the *fixed effects* (FE) model can be used. This model includes an individual intercept (α_i) for each country (i), which controls for individual-specific and time-invariant characteristics. If we use FE, it means that we assume observations within the individual could have an impact or bias the independent or dependent variables and thus a control is needed More precisely, fixed effects assume that there is a correlation between countries' error terms and the independent variables. Then, FE remove the effect of those time-invariant characteristics in order to be able to correctly estimate the net effect of the predictors on the outcome variable. (Torres-Reyna, 2007)

The fixed effects model $$y_{it} = \alpha_i + \beta_1 x_{1_{it}} + \cdots + \beta_k x_{k_{it}} + u_{it}$$

Moreover, apart from this country-specific effects, observations from a same period of time, in our case, from a same year, can also be correlated. The presence of time effects can lead to cross-sectionally correlated error terms[8] and thus biased results. A solution that economists often opt for is to add time dummies to capture these common time effects. In the presence of such a fixed time effects model, the impact of time effects on economic factors is fixed (the same) for each country. It allows common time trends to influence all observations. Nevertheless, a drawback of using time fixed effects is that a greater part of variation is lost during the process. When time dummies are added, the inter-temporal divergences are neutralized and the estimates exclusively explain the intra-temporal variance. In a more formal econometric language, the fixed effects estimator is also called the *within* estimator as it ignores the between variance and only takes into account within variance. (Sojli, Tham & Wang, 2018)

There exists another way to analyse observations from a panel data, which is called *random effects* (RE). This time, the RE estimator uses both the between and within variation.

The random effects model $$y_{it} = \alpha + \beta_1 x_{1_{it}} + \cdots + \beta_k x_{k_{it}} + u_{it} + \varepsilon_{it}$$ [9]

The drawback of this model is that it will only be consistent if the individual affects are uncorrelated with the explanatory variables. In practice, the random effects estimator is not often used to analyse demographics and economic variables.

In order to decide for which of those two models (fixed effects or random effects) we will choose to perform our regressions, we will rely on a specific test developed by Hausman in 1978 and therefore called the Hausman test. The null hypothesis behind this test is that the dependent variables are not correlated with the unique errors and therefore the most efficient model is the random effects model. (Greene, 2008, p. 80) In our case, the p-values from the Hausman test performed on our models are lower than 0.05 for two of them (models

[8] That is, for a same year, the error terms between countries are correlated (Cov(u_{it}, u_{jt}) ≠ 0 ; for some i ≠ j)

[9] Where u_{it} is the between-entity error and ε_{it} is the within-entity error

having GDP per capita growth and inflation as independent variables) which means that we reject the null hypothesis and the fixed effects model is recommended. The debt-to-GDP model has a p-value higher than 0.05 and the random effects model is preferred. The real exception is for the model which studies the household saving rate as dependent variable. Indeed, the random effects model requires the existence of strictly more individuals (countries in our case) than the number of independent variables (incl. intercept). As our data are limited for this one variable and we only focus on five countries, the random effects model cannot be applied and we automatically go for the fixed effects model (see Table 3).

Models (dependent variable tested)	**p-value**
GDP per capita growth rate	0.002952
Household saving rate	/
Debt-to-GDP ratio	0.4751
Inflation	1.809e-06

Table 3. Results of the Hausman test

For the three models which will use FE regressions, it is important to check whether adding time dummies into the model is needed, as we have discussed above. In order to do so, we will perform a F (Fischer) test. The null hypothesis is that time dummies are not needed and a simple fixed effects model is consistent. The obtained results show that we reject this hypothesis and we need to use a time fixed effects (see Table 4). Appendix B gives an overall view of the different models used.

Models (dependent variable tested)	p-value
GDP per capita growth rate	< 2.2e-16
Household saving rate	2.403e-05
Inflation	< 2.2e-16

Table 4. Results of the F test

We now know which model we can use to perform our regressions. But before we do so, it is important to analyse the time series properties of both the dependent and independent variables. A major issue that could be overlooked in empirical studies is indeed the stationarity of the data. A process is stationary if the mean, the variance and the autocorrelation structure do not change over time. One of the reasons why a process is nonstationary could be the presence of *unobserved common errors*. Indeed, some relevant variables might have been omitted from the model. It is almost impossible to measure all relevant variables, meaning that these unobserved errors are also omitted. As those errors could be nonstationary, the results of a regression might be biased and therefore not consistent.

In order to test whether our variables contain such nonstationary pattern, we will use the *augmented Dickey-Fuller* (ADF) unit root tests. The null hypothesis of the test is the presence of a unit root in the cross-sections of our database. If the p-value of the test is less than 0.05, it means that there is no unit root present in the observations and that the variable can be considered as stationary. The application of this test on our data, as shown in Table 5, returns p-values lower than 0.05 for each variables, meaning that the null hypothesis can be rejected and the variables can be considered as stationary. The reasons why the p-values of our independent variables change between model 1 and the other ones is because our data were limited in the case of household saving rate. Therefore, the number of observations also changed, which has an impact on the results of this test. However, we observe that the variables are still stationary.

Variables	**p-values**			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Dependent				
Household saving rate	0.04873			
GDP per capita growth rate		0.01		
Debt-to-GDP ratio			0.04282	
Inflation				0.01
Independent				
Old-age dependency ratio	0.02196		0.02692	
Life expectancy	0.01		0.01	
Population growth	0.01		0.01334	
Share of “old” people (65+)	0.026		0.03776	
Share of “older” people (80+)	0.01846		0.01	

Table 5. Results of the augmented Dickey-Fuller test

Chapter II : Results and discussion

In this chapter, we will first investigate the results coming from each of the regressions that we have performed based on the methodology and the data described in the previous chapter. Afterwards, we will make an overall discussion by assembling the different results from these four regressions together and observe whether a common impact present the limitations that we have faced during this empirical research.

2.2.1 Results

First model : GDP per capita growth

The first model that we have developed is the impact of our five demographic variables (old-age dependency ratio, life expectancy, share of people over 65, share of people over 80 and population growth) on the growth of GDP per capita growth, in the same way as Peterson (2017), Yoon et al. (2014) and Maestas et al. (2016) did. The hypothesis according to those three researches is that an ageing population leads to a lower GDP per capita growth.

Table 6 presents our own statistical results for this model.

Variables	**GDP per capita growth – time fixed effects**	
Old-age dependency ratio	-0.39602 (-1.4004)	
Life expectancy	-0.46221 (-1.7224)	.
Population growth	0.62795 (1.2494)	**
Share of “old” people (65+)	-0.82270 (-1.8420)	
Share of “older” people (80+)	-0.94513 (-3.1831)	.
R^2	0.06555	

*Note: t-statistics are in parentheses, . indicates significance at the 10% level, * at the 5% level, ** at the 1% level and *** at the .1% level.*

Table 6. Estimation results for the GDP per capita growth model.

Following the results from the model above, the impact of our demographic variables on GDP per capita growth is quite limited. Indeed, including our five different variables, only one of them is found to be significant over the 5% level and two others at the 10% level.

One of those two less significant variables is the share of people aged 80 and over. The estimate for this variable is negative, it is therefore negatively correlated with GDP per capita growth. That means that the output per capita is lower as a larger part of the population becomes 80 years old or even older. We also notice that, even if it is not significant, the estimate for the share of people over 65 is also negative. This result confirms what we had found in the literature, and mainly by Maestas et al. (2016). According to them, this negative relationship is mainly due to a lower productivity at an advanced age and also a slower growth in labour force.

Besides that, life expectancy is the second significant variable at a 10% level. This one also has a negative estimate. The fact that people are born with a higher chance of living a long life seems to be negative for the growth of GDP per capita. It goes along with what was said earlier

as it shows that those people are more likely to reach the age of 65 or even 80 and therefore result in a lower GDP per capita.

Finally, the variable that is significant at a 1% level, and thus the most significant one of our model, seems to be population growth. Unlike all the other variables, this one is positively correlated with the output per capita. It means that as the number of people inside a population increases, the aggregate output that is produced by those also grows. However, in the cases where population growth is sometimes decreasing such as this is the case in Europe as reported in the first section of this thesis, output becomes therefore less important.

Overall, the share of old people and life expectancy tend to increase in European countries and those have a negative impact on output per capita while population growth, which is positively correlated with output per capita, is declining. Therefore, we can conclude that GDP per capita growth is negatively impacted by the population ageing phenomenon as it was found by Peterson (2017), Yoon et al. (2014) and Maestas et al. (2016). However, we have to be careful not to make this as a generality because our predictive power (R^2) is very small.

Second model : household saving rate

The second model that has been tested is the impact of the same demographic factors on another economic variable, which is the household saving rate. It is quite hard to give an hypothesis with this model as many studies treating this relationship were conducted but the results are quite divergent. According to Callen et al. (1997) and Loayza et al. (2000), there should be a negative effect between ageing and this saving rate. However, other authors, namely Börsch-Supan et al. (2000), found a positive relationship between those in the case of Germany. The results of our model could help us to judge whether these views go along with our data.

Table 7 shows the results of our regression.

Variables	**Household saving rates – time fixed effects**	
Old-age dependency ratio	-2.81558 (-4.5905)	***
Life expectancy	-1.50773 (-2.7365)	**
Population growth	-1.16961 (5.0411)	***
Share of “old” people (65+)	5.32738 (-5.9987)	***
Share of “older” people (80+)	-5.64592 (-1.6597)	.
R^2	0.32099	

*Note: t-statistics are in parentheses, . indicates significance at the 10% level, * at the 5% level, ** at the 1% level and *** at the .1% level.*

Table 7. Estimation results for the household saving rates model.

As we can see, all our variables are significant at least at a 10% level.

We will begin our analyse with the results of our first demographic variable, the old-age dependency ratio, which is significant at a 0.1% confidence level. The estimate for this variable is negative. It means that, if more people are reaching the age of 65, and thus the age of retirement, while working-age population does not grow, then household saving rates will undergo a substantial decrease. It is in respect with the *life-cycle hypothesis* developed by Modigliani et al. (1954), which states that middle-aged people tend to save more than young and older people.

Life expectancy is our second variable. It is significant at a 1% level and also seems to be negatively correlated with the household saving rates. It signifies that as long as life expectancy increases, as it is the case in Europe, the household saving rates decrease. It supports the results from the previous variable in the sense that if people get to live longer but do not adjust their working life in order to retire later, they will begin to use their savings to start consuming directly, which will then decrease their saving rates.

Thirdly, we also observe a negative impact of population growth, which is a significant variable at a 0.1% level, on our saving rates. It means that the more people there are inside a population, the less households will tend to save. If we follow the logic that population growth leads to more dependent children but also more elderly due to longer life expectancy inside households, it also means that the proportion of savers tend to decrease, which explains this relationship. However, we have to remind that Europe has known very slow population growth lately, substantially due to low fertility rates. Some European countries even had a negative population growth rate for some years, which would then lead to higher savings rates as less children are born. Another component of population growth is migration. As we said in the first section, there is a phenomenon of net immigration inside Europe, which could help bring younger people inside its population. However, as it is quite complex to know the age structure of people immigrating, we will thus not take immigration into account when talking about the effect of population growth on our economic variables.

Finally, the share of people over 65 years old seems to be positively correlated with the household saving rates. It shows that people who have just retired or who still work will tend to keep on saving in order to keep those savings for their older days. This is confirmed by the negative relationship existing between the share of older people (who are over 80 years old) and those saving rates. Indeed, it proves that people continue on saving even after retirement but, at a certain time, they start to need those to cope with the higher quantity of spending occurring at the end of their lives. However, we notice that the variable representing the share of people over 65 is more significant than the one for the older population (80+), this one being therefore a less reliable explanation.

As a summary, we observe that demographic factors definitely have an impact on household saving rates. However, even if most of our results seem to show an overall negative relationship between ageing and household saving rates, it is still a subject of matter, substantially because of the positive relationship found for the variable concerning the share of people over 65.

Third model : Debt-to-GDP ratio

Our third model tests the relationship between our demographic factors and the ratio between public debt and gross domestic product. According to what has been said in our literature review and to the findings of Jackson et al. (2017), our hypothesis is that population ageing makes the debt-to-GDP ratio increase, notably by increasing the public debt.

The results can be seen in Table 8.

Variables	**Debt-to-GDP ratio – random effects**	
(Intercept)	-131.5943 (-1.7964)	.
Old-age dependency ratio	2.8455 (0.6846)	
Life expectancy	2.4965 (2.2313)	*
Population growth	-24.0800 (-12.3966)	***
Share of “old” people (65+)	-4.3859 (-0.6068)	
Share of “older” people (80+)	5.0298 (1.7301)	.
R^2	0.62495	

*Note: z-statistics are in parentheses, . indicates significance at the 10% level, * at the 5% level, ** at the 1% level and *** at the .1% level.*

Table 8. Estimation results for the debt-to-GDP ratio model.

First of all, we observe that in our five variables, only three of them are significant at the 10% confidence level. Let us start with life expectancy, one of those three significant variables. The relationship between this one and the debt-to-GDP ratio seems to be positive. It goes along with our hypothesis as, if people tend to live longer, governments will need to develop their healthcare and pension spending. As we have seen in the previous section, this will make the public debt rise if the public revenues do not follow.

The second significant variable is the share of older people (over 80 years old). As we could expect, it has a positive effect on the debt-to-GDP ratio. Indeed, as more people of a population reach the age of 80, those do not contribute to public revenues as much as younger people would. They often benefit from tax reduction when it comes to healthcare spending due to their older age. That also makes the public expenditure increase. In the end, the two phenomena lead to a higher debt-to-GDP ratio.

The most significant of those three variables is population growth. This one seems to have the most important impact on the debt-to-GDP ratio by being negatively correlated with this ratio. If we follow the same logic we used for our second model, saying that population growth is leading to more dependent children, this negative relationship is quite surprising as we could think that those would help rising public debt rather than making it decline as more spending has to be done on education, infrastructure, etc. However, a higher population growth could also mean a higher workforce in the future as those children will likely become workers when they become adults, then declining public debt as they allow to produce more public revenues. Besides that, if the population growth is very low or negative as it has been the case in the ageing Europe, the debt-to-GDP ratio is expected to grow. This explanation can thus reinforce the results from the other two significant variables by saying that higher public debt can also come from a negative population growth or at least that public debt is not really impacted that much from population growth if this one is extremely low.

In the end, we could conclude the analysis of this model by being tempted to say that there exists an overall positive relationship between ageing and the debt-to-GDP ratio, substantially due to our first two variables. However, we have to be careful about the interpretation of the population growth variable. This last one being the most significant, it is hard to give a clear statement.

Fourth model : Inflation

Our last model concerns the impact of the same demographic variables as for the first three tests but this time on inflation. As said in the previous section, there is no clear answer to whether this relationship is positive or negative. As a reminder, Botman et al. (2014) and Yoon et al. (2014) found out that ageing helps reducing inflation while the results of Juselius et al.

(2015) show that "younger old" people (between 65 and 80) are inflationary, in contrast to the very old (80+) who are deflationary. We will therefore analyse our results to help deciding which of those two statements should be followed.

The results of our regression are shown in Table 9.

Variables	**Inflation – time fixed effects**	
Old-age dependency ratio	-2.83842 (-10.7999)	***
Life expectancy	-1.13116 (-4.5354)	***
Population growth	1.58150 (5.7310)	***
Share of "old" people (65+)	-5.38800 (-11.5352)	***
Share of "older" people (80+)	-0.99233 (-2.3906)	*
R^2	0.49348	

*Note: t-statistics are in parentheses, . indicates significance at the 10% level, * at the 5% level, ** at the 1% level and *** at the .1% level.*

Table 9. Estimation results for the inflation model.

We firstly notice that four of our variables (old-age dependency ratio, life expectancy, population growth and the share of people over 65) are significant at a 0.1% confidence level while the other one, the share of people over 80, is significant at a 5% level.

We will begin our analysis with the variable representing the old-age dependency ratio. On the basis of our results, we observe that this one is negatively correlated with the inflation. As the share of retirees compared to the working-age people increases, inflation seems to be impacted by being pushed downward. It confirms the fact that workers seem to be inflationary while elders are disinflationary.

On top of that, the share of people over 65 and over is, as we could expect, also negatively related to inflation. This is also the case for the share of older people, but the impact seems

to be less important as the estimate is smaller than the ones for the share of “younger old” people. Our hypothesis based on the work of Juselius et al. (2015) was that more people over 80 years old leads to deflation while more people between 65 and 80 years old leads to inflation. This statement thus does not apply to our own results.

In the same way, the estimate of life expectancy is negative. The fact that people expect to live a longer life seems to impact inflation by reducing it. It goes along with the results from the previous variable as a rise in life expectancy leads to more aged people combined with less working-age people if fertility rates does not go up. That is expected to have a disinflationary or even deflationary effect if it follows the same path as Japan, as studied by Bobeica et al. (2017).

Finally, population growth is the only variable with a positive estimate. Therefore, a growth in population could help putting inflation up and could counterbalance the effects of ageing.

Overall, we can say that our results follow a same path by showing that inflation is negatively impacted by an ageing population.

Discussion: the overall impact of ageing on our economic factors

After having analysed the results from our four different models, it is interesting to have a better look at the bigger picture. That will allow us to define if we can genuinely draw conclusions about the general effect of population ageing on the European economy and if it can be seen as one of the reasons behind the current economic slowdown, represented by the secular stagnation concept.

Within those four models, three of them could definitely be considered as evidence for the negative impact of population ageing on economic growth.

The first one is the GDP per capita growth model, GDP per capita representing the growth in output generated by workers. As we have seen in the previous section and thus in different researches from other authors, the actual economic slowdown is partly due to a lower output, which is itself a consequence of population ageing as we have seen in our results.

The second one is the inflation model. The analysis of this model leads to the conclusion that population ageing has a negative impact on inflation. The fact that Europe has been facing a period of very low inflation and even sometimes deflation could then be explained, not entirely but to a certain extent, by the ageing of its population.

Concerning the debt-to-GDP ratio model, it seems to be positively correlated with the variables representing the ageing such as life expectancy and the share of people over 80 but the negative relationship with population growth is a bit less obvious. However, as ageing can also characterized by very low population growth, the impact should be either minimal or, in cases where population growth is negative, even follow the same sense as the other two variables.

As we have seen, secular stagnation is characterized by a slow economic growth partly due to low output and low inflation. Public debt is also seen as a cause of the economic slowdown. Therefore, those three models seem to support the idea that population is one of the causes of the secular stagnation phenomenon.

However, one of the basis effects of secular stagnation is also excess savings accompanied by low investment, as said by Hansen (1939), and our results for the household saving rates do not seem to support the idea that population ageing leads to higher saving rates. This is thus the only model which does not go along with a potential link between ageing and the secular stagnation concept.

2.2.2 Limitations

Even if the results presented in the empirical part of this thesis appear to be quite interesting, we have to be careful as those also involve limitations that we faced during our work and that we now have to take into account.

The main limitation that we faced, and surely the most constraining, is the availability of the required data to perform our empirical models. Indeed, it would have been interesting, and certainly more accurate, to have data which are collected frequently, such as quarterly or biannual observations. However, those are not necessarily available for each needed variable. Therefore, we had to cope with only yearly observations. While it is not a real problem for

demographic variables, as those are not to reactive and are more long-term changing, it can be a more important struggle for economic variables which are way more reactive and frequently change.

This struggle actually generates another one. As frequent observations were not available, we had to be sure to have data for a sufficient time period in order to fill in the gaps. The most recent observations that we could have were from 1981. The period therefore consists in 37 years, which is actually not that long for this kind of research. Even inside this short period, some observations were missing in the database. However, those missing values were quite rare and they are not expected to have a critical impact on our final results.

On top of that, those observations were only available for a small portion of countries from the euro area. For example, data from the Eastern European countries which are now part of the euro area were logically not available for our period. Hence, the number of countries that we could analyse was smaller than what was expected and the sample mainly consists in Western European countries. The problem is even more important for the household saving rates model, for which we only disposed of observations from five countries. The struggle that follows is that it would be incorrect to take this selection of countries as a representation of the euro area as each country has its own specificity.

Conclusion

The objective of this thesis was to investigate the potential link that might exist between the current population ageing phenomenon and the economic environment of the euro area which has not been in its best shape lately.

Our literature review helped us understand how European countries are experiencing a rise in their population age and how it is not planned to stop, even in a long-term period.

Besides that, European countries have known a period of recession in recent years, substantially due to the financial crisis that started in 2007. The struggle is that the economy seems to have troubles recovering from this period. The economic growth is still very low, coupled with low interest rates and low inflation. Hence, more and more economists have been using the concept of secular stagnation to represent this particular economic situation. Most of those economists believe that population ageing is one of the reasons behind the difficulty of recovering from this crisis.

In order to contribute to this subject, we have selected a well-defined number of Eurozone countries from which we have collected data for five demographic variables, namely old-age dependency ratio, population growth, life expectancy, share of old people (over 65 years old) and share of older people (over 80 years old). Afterwards, we have tested the relationships between those variables and four economic factors: GDP per capita growth, household saving rates, debt-to-GDP ratio and inflation.

The results coming from the different regressions that we have applied on our data support the idea that demographic trends are one of the forces that shape the economic environment in which monetary policy operates. However, the way that economic factors are affected varies between our four models. The first model concerns the GDP per capita and we can see that ageing has a negative effect on this variable, which can be considered as one of the predictors of economic growth. Our second model studies the impact on household saving rates. The results from this one are a bit more complicated to estimate even though population ageing seems to reduce saving rates in general. The following model is about the debt-to-GDP ratio. As it was assumed, according to our results, population ageing leads to a

higher debt-to-GDP ratio, probably due to more public debt and less public revenues. Finally, our last model aims at determining whether ageing leads to a rise or a decline in inflation. We have found out that demographics definitely play a role in the low inflation that Europe is facing as inflation is negatively correlated with population ageing.

Overall, a majority of those models show a negative impact of population ageing on the economy, even though the one studying household saving rates seems to have quite the opposite effect. However, it is important to keep in mind that the sample we used in order to conduct our empirical research cannot be seen as a perfect representation of the whole euro area or of the European Union. As these organisms are still quite young and some of the Member States joined the Union not that long ago, having access to relevant data was quite complex. This might lead to biased results and has to be taken into account.

The European Central Bank is well aware of the ageing effect on economy. However, their possibilities to apply traditional monetary policies are limited, substantially due to the Zero Lower Bound. Hence, only unconventional policies help mitigate the effects. Two examples are a targeted quantitative easing program, which consists in injecting liquidity into the economy to stimulate demand, and increased public investment. (Wolff, 2014)

Other European institutions also have the possibility to apply solutions that would not be economic ones but could still have a major impact on the European economic environment. One of those solutions would be to rise the quotas for legal immigration. Having more young or middle-aged people from other continents that do not face this ageing problem could help to mitigate the worrying situation. Indeed, that might help to decrease, or at least slow down, the growth in the share of elderly inside European countries. Another possibility would be to increase the legal age of retirement in line with life expectancy. Workers retiring a few years later than they do now would not make the constant growth of elderly stop, but might help by postponing the age at which pension benefits are granted and by increasing the labour supply. Those actions would have be to be harmonized and should be decided at a European level to be even more effective.

We are aware that this thesis will not allow to find a simple solution to the problem of the ageing population inside Europe, as this subject is undeniably complex. However, it could be

seen as a basis for future projects. As a recommendation, it would be interesting to simulate the potential benefits of the solutions mentioned above by including those in our model.

References

Aiyar, S., & Ebeke, C. (2016). The Impact of Workforce Aging on European Productivity. *IMF Working Papers, 16*. doi:10.5089/9781475559729.001

Andersson, M., Szörfi, B., Tóth, M., & Zorell, N. (2018). Potential output in the post-crisis period. *ECB Economic Bulletin, Issue 7/2018*, p. 49-70. doi:10.2866/15875

Ando, A., & Modigliani, F. (1963). The "Life Cycle" Hypothesis of Saving: Aggregate Implications and Tests. *The American Economic Review, 53*(1), 55-84. Retrieved from http://www.jstor.org/stable/1817129

Authers, J. (2016). Demographics and markets: The effects of ageing. *Financial Times*. Retrieved from https://www.ft.com/content/df61dc42-99fa-11e6-8f9b-70e3cabccfae

Baldwin, R., & Teulings, C. (2014). Secular stagnation: facts, causes and cures. *London: Centre for Economic Policy Research-CEPR*.

Bertrand, M., & Morse, A. (2013). Trickle-Down Consumption. *National Bureau of Economic Research Working Paper Series, No. 18883*. doi:10.3386/w18883

Boersch-Supan, A. H., & Winter, J. K. (2001). Population Aging, Savings Behavior and Capital Markets. *National Bureau of Economic Research Working Paper Series, No. 8561*. doi:10.3386/w8561

Borsch-Supan, A., & Essig, L. (2003). Household Saving in Germany: Results of the first SAVE study. *National Bureau of Economic Research Working Paper Series, No. 9902*. doi:10.3386/w9902

Börsch-Supan, A., Reil-Held, A., Rodepeter, R., Schnabel, R., & Winter, J. K. (2000). Household Savings in Germany. Retrieved from https://EconPapers.repec.org/RePEc:wpa:wuwpma:0004053

Bossone, B. (2015). The 'safety trap' and Eurozone secular stagnation. Retrieved from the Web site of World Bank Blogs https://blogs.worldbank.org/allaboutfinance/safety-trap-and-eurozone-secular-stagnation

Breusch, T. S., & Pagan, A. (1980). The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics. *Review of Economic Studies, 47*(1), 239-253. Retrieved from https://EconPapers.repec.org/RePEc:oup:restud:v:47:y:1980:i:1:p:239-253.

Caballero, R. J., & Farhi, E. (2014). On the role of safe asset shortages in secular stagnation. *Secular Stagnation: Facts, Causes and Cures*, 111-122.

Caballero, R. J., Farhi, E., & Gourinchas, P.-O. (2016). Safe Asset Scarcity and Aggregate Demand. *National Bureau of Economic Research Working Paper Series, No. 22044*. doi:10.3386/w22044

Callen, T., & Thimann, C. (1997). Empirical Determinants of Household Saving : Evidence From OECD Countries. *IMF Working Papers, 97*(181). Retrieved from https://www.imf.org/en/Publications/WP/Issues/2016/12/30/Empirical-Determinants-of-Household-Saving-Evidence-From-OECD-Countries-2454

Canon, M., Kudlyak, M., & Reed, M. (2015). Aging and the Economy: The Japanese Experience. *The Regional Economist*(Oct), 12-13. Retrieved from https://EconPapers.repec.org/RePEc:fip:fedlre:00091

Cervellati, M., Sunde, U., & Zimmermann, K. F. (2017). Demographic dynamics and long-run development: insights for the secular stagnation debate. *Journal of Population Economics, 30*(2), 401-432. doi:10.1007/s00148-016-0626-8

Chawla, M., Betcherman, G., & Banerji, A. (2007). *From Red To Grey*. Washington, D.C.: The World Bank, p.117-150.

Cook, C. J. (2005). Population growth and savings rates: Some new cross-country estimates. *International Review of Applied Economics, 19*(3), 301-319. doi:10.1080/02692170500119755

Derek, A., Dennis, P. B., & Benjamin, L. H. (2014). Is Japan's Population Aging Deflationary? doi:DOI:

Drechsel-Grau, M., & Schmid, K. (2014). Consumption–savings decisions under upward-looking comparisons. *Journal of Economic Behavior & Organization, 106*(C), 254-268. Retrieved from https://EconPapers.repec.org/RePEc:eee:jeborg:v:106:y:2014:i:c:p:254-268

Dufrenot, G., & Rhouzlane, M. (2018). Secular Stagnation: New Challenges for the Industrialized Countries in the 21st Century. Retrieved from https://EconPapers.repec.org/RePEc:aim:wpaimx:1818

Eggertsson, G. B., & Krugman, P. (2012). Debt, Deleveraging, and the Liquidity Trap: A Fisher-Minsky-Koo Approach*. *The Quarterly Journal of Economics, 127*(3), 1469-1513. doi:10.1093/qje/qjs023

Eggertsson, G. B., & Mehrotra, N. (2014). A model of secular stagnation. *Secular Stagnation: Facts, Causes and Cures*, p. 123-129. Retrieved from https://voxeu.org/article/secular-stagnation-facts-causes-and-cures-new-vox-ebook

Eggertsson, G. B., Mehrotra, N. R., & Summers, L. H. (2016). Secular Stagnation in the Open Economy. *National Bureau of Economic Research Working Paper Series, No. 22172*. doi:10.3386/w22172

England, K., & Azzopardi-Muscat, N. (2017). Demographic trends and public health in Europe. *European Journal of Public Health, 27*(suppl_4), 9-13. doi:10.1093/eurpub/ckx159

European Central Bank. (2019). *2018 Annual Report*. Retrieved from https://www.ecb.europa.eu/pub/annual/html/index.en.html

European Commission. (2014). *The 2015 Ageing Report : Underlying Assumptions & Projection Methodologies*. Luxembourg: Publications Office of the European Union.

European Commission. (2017). *The 2018 Ageing Report : Underlying Assumptions & Projection Methodologies*. Luxembourg: Publications Office of the European Union.

Eurostat. (2019a). Population structure and ageing. Retrieved from the Web site of Eurostat http://ec.europa.eu/eurostat/statistics-explained/index.php/Population_structure_and_ageing

Eurostat. (2019b). Migration and migrant population statistics. Retrieved from the Web site of Eurostat https://ec.europa.eu/eurostat/statistics-explained/index.php/Migration_and_migrant_population_statistics

Favero, C. A., & Galasso, V. (2015). Demographics and the Secular Stagnation Hypothesis in Europe. Retrieved from https://ideas.repec.org/p/cpr/ceprdp/10887.html

Ferrero, G., Gross, M., & Neri, S. (2017). On secular stagnation and low interest rates: Demography matters. *International Finance*. doi:10.1111/infi.12342

Fontan, S. (2014a). Zone euro: de la désinflation au risque de déflation. Retrieved from the Web site of Economie Matin http://www.economiematin.fr/news-economie-union-monetaire-deflation-desinflation-zone-euro-bce-entreprises-marches-consommation-investissement-taux-interet-emplois-politique-monetaire

Fontan, S. (2014b). Histoire de l'évolution de l'inflation en zone euro. Retrieved from the Web site of L'Economiste https://www.leconomiste.eu/decryptage-economie/186-histoire-de-l-evolution-de-l-inflation-en-zone-euro.html

Gordon, R. J. (2012). Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds. *National Bureau of Economic Research Working Paper Series, No. 18315*. doi:10.3386/w18315

Gordon, R. J. (2015). Secular Stagnation: A Supply-Side View. *American Economic Review, 105*(5), 54-59. Retrieved from https://EconPapers.repec.org/RePEc:aea:aecrev:v:105:y:2015:i:5:p:54-59

Greene, W. H. (2008). *Econometric Analysis (6th Edition)*: Pearson Education.

Hansen, A. H. (1939). Economic Progress and Declining Population Growth. *The American Economic Review, 29*(1), 1-15. Retrieved from http://www.jstor.org/stable/1806983

Hondroyiannis, G., & Papapetrou, E. (1999). Fertility choice and economic growth: Empirical evidence from the U.S. *International Advances in Economic Research, 5*(1), 108-120. Retrieved from https://EconPapers.repec.org/RePEc:kap:iaecre:v:5:y:1999:i:1:p:108-120:10.1007/bf02295036

Hsiao, C. (2007). Panel data analysis—advantages and challenges. *TEST, 16*(1), 1-22. doi:10.1007/s11749-007-0046-x

Jackson, T., Clemens, J., & Palacios, M. (2017). Canada's Aging Population and Implications for Government Finances. Retrieved from https://www.fraserinstitute.org/studies/canadas-aging-population-and-implications-for-government-finances

Jones, C. (2018). Aging, Secular Stagnation and the Business Cycle. *IMF Working Papers, 18*, 1. doi:10.5089/9781484345405.001

Juselius, M., & Takáts, E. (2016). The age-structure–inflation puzzle. doi:DOI:

Landau, J.-P. (2014). Why is euro inflation so low? Retrieved from the Web site of Vox https://voxeu.org/article/why-euro-inflation-so-low

Lauwers, D. (2018). *The effect of demograhic change on household savings, with macroeconometric analysis.* Universiteit Gent,

Lawrence, H. S. (2015). Demand Side Secular Stagnation. *American Economic Review, 105*(5), 60-65. Retrieved from https://ideas.repec.org/a/aea/aecrev/v105y2015i5p60-65.html

Lee, R. D. (2017). Demographic Transition. In *The New Palgrave Dictionary of Economics* (pp. 1-8). London: Palgrave Macmillan UK.

Leon, D. A. (2011). Trends in European life expectancy: a salutary view. *International Journal of Epidemiology, 40*(2), 271-277. doi:10.1093/ije/dyr061

Loayza, N., Schmidt-Hebbel, K., & Servén, L. (2000). What Drives Private Saving Across the World? *The Review of Economics and Statistics, 82*(2), 165-181. Retrieved from https://EconPapers.repec.org/RePEc:tpr:restat:v:82:y:2000:i:2:p:165-181

Maestas, N., Mullen, K. J., & Powell, D. (2016). The Effect of Population Aging on Economic Growth, the Labor Force and Productivity. *National Bureau of Economic Research Working Paper Series, No. 22452*. doi:10.3386/w22452

Mikael, J., & Elod, T. (2015). Can demography affect inflation and monetary policy? Retrieved from https://ideas.repec.org/p/bis/biswps/485.html

Mitchell, C. (2019). Zero-Bound. Retrieved from the Web site of Investopedia https://www.investopedia.com/terms/z/zero-bound.asp

Modigliani, F., & Brumberg, R. (1954). Utility Analysis and the Consumption Function: An Interpretation of Cross Section Data. *Post Keynesian Economics*.

Mućk, J. (2018). Econometrics of Panel Data. Retrieved from https://web.sgh.waw.pl/~jmuck/EconometricsOfPanelData.html

Nagarajan, R., Teixeira, A., & Silva, S. (2013). The impact of an ageing population on economic growth: an exploratory review of the main mechanisms. Retrieved from https://EconPapers.repec.org/RePEc:por:fepwps:504

Nerlich, C., & Schroth, J. (2018). The economic impact of population ageing and pension reforms. *ECB Economic Bulletin, Issue 2/2018*, p. 85-109. doi:10.2866/0073

Nickel, C., Bobeica, E., Lis, E., & Sun, Y. (2017). Demographics and inflation. *Working Paper Series, 2006*. Retrieved from https://ideas.repec.org/p/ecb/ecbwps/20172006.html

Papetti, A. (2019). Demographics and the natural real interest rate: historical and projected paths for the euro area. Retrieved from https://ideas.repec.org/p/ecb/ecbwps/20192258.html

Peterson, E. W. F. (2017). The Role of Population in Economic Growth. *SAGE Open, 7*(4), 2158244017736094. doi:10.1177/2158244017736094

Pigou, A. C. (1943). The Classical Stationary State. *The Economic Journal, 53*(212), 343-351. doi:10.2307/2226394

Probst, J. (2019). Secular stagnation: it's time to admit that Larry Summers was right about this global economic growth trap. Retrieved from the Web site of The Conversation https://theconversation.com/secular-stagnation-its-time-to-admit-that-larry-summers-was-right-about-this-global-economic-growth-trap-112977

Romel, V. (2018). How Japan's ageing population is shrinking GDP. Retrieved from the Web site of Financial Times https://www.ft.com/content/7ce47bd0-545f-11e8-b3ee-41e0209208ec#comments-anchor

Roser, M. (2019). Life expectancy. *Our World in Data*. Retrieved from https://ourworldindata.org/life-expectancy

Santamaria, C., Tintori, G., & Vespe, M. (2019). Migration data in Europe. Retrieved from the Web site of Migration Data Portal https://migrationdataportal.org/regional-data-overview/europe

Sojli, E., Tham, W. W., & Wang, W. (2018). Market-wide Events and Time Fixed Effects. Retrieved from https://editorialexpress.com/cgi-bin/conference/download.cgi?db_name=CICF2018&paper_id=1141

Summers, L. (2013). *IMF Fourteenth Annual Research Conference in Honor of Stanley Fischer*. http://larrysummers.com/2013/11/08/imf-fourteenth-annual-research-conference-in-honor-of-stanley-fischer/

Summers, L. H. (2014). U.S. Economic Prospects: Secular Stagnation, Hysteresis, and the Zero Lower Bound. *Business Economics, 49*(2), 65-73. doi:10.1057/be.2014.13

Summers, L. H. (2016). The Age of Secular Stagnation: What It Is and What to Do about It How to Survive Slow Growth. *Foreign Affairs*(2), 2-9. Retrieved from https://heinonline.org/HOL/P?h=hein.journals/fora95&i=235

https://heinonline.org/HOL/PrintRequest?handle=hein.journals/fora95&collection=journals&div=26&id=235&print=section&sction=26

Tim Searchinger, C. H., Richard Waite, Brian Lipinski, George Leeson, Sarah Harper. (2013). Achieving Replacement Level Fertility. *Working Paper, Installment 3 of Creating a Sustainable Food Future*. Retrieved from http://www.worldresourcesreport.org.

Torres-Reyna, O. (2007). Panel data analysis fixed and random effects using Stata (v. 4.2). *Data & Statistical Services, Priceton University*.

Van Bavel, J., & Reher, D. S. (2013). The Baby Boom and Its Causes: What We Know and What We Need to Know. *Population and Development Review, 39*(2), 257-288. doi:10.1111/j.1728-4457.2013.00591.x

Werner, R. (2014). ECFIN's medium term projections: the risk of « secular stagnation ». *Quarterly Report on the Euro Area (QREA), 13*(4), 23-29. Retrieved from https://ideas.repec.org/a/euf/qreuro/0134-02.html

Wessel, D., & Olson, P. (2015). The Hutchins Center Explains: the Natural Rate of Interest. *Brookings*. Retrieved from https://www.brookings.edu/blog/up-front/2015/10/19/the-hutchins-center-explains-the-natural-rate-of-interest/

Wolff, G. B. (2014). Monetary policy cannot solve secular stagnation alone. *Secular Stagnation: Facts, Causes and Cures*, p. 143-150. Retrieved from https://voxeu.org/article/secular-stagnation-facts-causes-and-cures-new-vox-ebook

Yoon, J.-W., Kim, J., & Lee, J. (2014). Impact of Demographic Changes on Inflation and the Macroeconomy. *IMF Working Papers, 14*, 1. doi:10.5089/9781498396783.001

Appendices

A. Data description and corresponding sources

***Debt-to-GDP ratio*:** Public debt as a percentage of the gross domestic product (GDP). Public debt is defined in the Maastricht Treaty as consolidated general government gross debt at nominal (face) value, outstanding at the end of the year.

Source: Eurostat database - Quarterly government debt (gov_10q_ggdebt)

***GDP per capita growth rate*:** Annual percentage growth rate of GDP per capita (gross domestic product divided by midyear population) based on constant local currency.

Source: World Bank database

https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG?view=chart

***Household saving rate*:** Net household saving is defined as household net disposable income plus the adjustment for the change in pension entitlements less household final consumption expenditure (households also include non-profit institutions serving households). The net household saving rate represents the total amount of net saving as a percentage of net household disposable income. All OECD countries compile their data according to the 2008 System of National Accounts (SNA).

Source: OECD database – National Accounts of OECD Countries, Volume 2019 Issue 1

***Inflation*:** Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. The Laspeyres formula is generally used.

Source: World Bank database https://data.worldbank.org/indicator/FP.CPI.TOTL.ZG

***Life expectancy*:** Mean number of years that a new-born child can expect to live if subjected throughout the rest of his or her life to the current mortality conditions (age-specific probabilities of dying).

Source: Eurostat database - Population (demo_mlexpec)

***Old-age dependency ratio*:** Ratio between the number of persons of an age when they are conventionally considered economically inactive (aged 65 years and over) and the number of persons conventionally considered of working age (respectively aged 15-64)).

Source: Eurostat database - Population (demo_pjanind)

***Population growth*:** Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage.

Source: World Bank database

https://data.worldbank.org/indicator/SP.POP.GROW?view=chart

Share of old people (65+): Number of people aged 65 years old or more compared to the whole population.

Source: Eurostat database - Population (demo_pjanind)

Share of older people (80+): Number of people aged 65 years old or more compared to the whole population.

Source: Eurostat database - Population (demo_pjanind)

B. Summary of the different models used

Models (dependent variable tested)	**Regression model used**
GDP per capita growth rate	Fixed effects with time dummies
Household saving rate	Fixed effects with time dummies
Debt-to-GDP ratio	Random effects
Inflation	Fixed effects with time dummies

LOUVAIN-LA-NEUVE | BRUXELLES | MONS | TOURNAI | CHARLEROI | NAMUR
Place des Doyens, 1 bte L2.01.01, 1348 Louvain-la-Neuve, Belgique | **www.uclouvain.be/lsm**