INSTITUTO
UNIVERSITÁRIO
DE LISBOA

The impact of demographic change on public debt rates in the Eurozone

Filipa Esteves Barreiro

Master's Degree in Monetary and Financial Economics

Advisor: Professor Doctor Sérgio Miguel Chilra Lagoa, Associate Professor with Aggregation
ISCTE - University Institute of Lisbon

September 2024

CIÊNCIAS SOCIAIS
E HUMANAS

Department of Political Economy

The impact of demographic change on public debt rates in the Eurozone

Filipa Esteves Barreiro

Master's Degree in Monetary and Financial Economics

Advisor: Professor Doctor Sérgio Miguel Chilra Lagoa, Associate Professor with Aggregation
ISCTE - University Institute of Lisbon

September 2024

"Die steigende Staatsverschuldung in alternden Gesellschaften ist eine der größten Herausforderungen für die Fiskalpolitik, da sie langfristig die finanzielle Stabilität gefährden kann."

(Translation from German)

"Rising public debt in ageing societies is one of the biggest challenges for fiscal policy, as it can jeopardise financial stability in the long term."

By Friedrich Heinemann (2008).

German economist specialising in public finance, fiscal policy and European economic governance.

Biographical Note

Filipa Esteves Barreiro was born in Lisbon on 31 October 2001. She grew up in Forte da Casa, where she completed her secondary education at Forte da Casa Secondary School in 2019. He completed his degree in Industrial Management and Logistics at ISCTE - University Institute of Lisbon in 2022. That year he took up a master's degree in Monetary and Financial Economics at the same faculty.

After the first year of his master's degree, in 2023, he started an internship at EDP - Global Solutions in the treasury department, in the Debt Management team. He stayed at EDP for 11 months and, on 10 April 2024, he embarked on another adventure. She started her internship at Baker Tilly Portugal in the accounting department, as an accounting assistant.

At the moment, he's trying to discover the world of accounting and his taste for it, with future projects and goals in mind.

Acknowledgements

The realization of this work was only possible with the help of several people whom I would like to thank.

Firstly, my parents, who have always supported me in every decision I have made and who have always been a source of admiration. Your effort, determination and affection have made me the person I am today and have been my greatest motivation for carrying out this work.

To my friends, for their encouragement, understanding, support and affection.

To all my teachers and colleagues at ISCTE who accompanied me on this long and hard journey, both during my bachelor's and master's degrees, for your availability, attention and sharing of knowledge. In particular, to Prof Sérgio Lagoa, for agreeing to be the supervisor of this work and whose help, attention, time and advice were crucial.

Finally, I would like to thank one of the most important people to me, my boyfriend, for his unconditional support, understanding, love, companionship and help throughout this process. I couldn't ask for a better partner to help me in my worst moments and accompany me in my best moments, like this one.

To all of you, my greatest thanks.

Resumo

Esta dissertação investiga principalmente a relação entre a dívida pública (DP), a despesa social (DS) e a população idosa (PI) nos países da Zona Euro, considerando também a influência de variáveis macroeconómicas adicionais, incluindo as taxas de juro das obrigações a 10 anos (TXj), a taxa de poupança (NSP) e a taxa de inflação (INF). A análise analisa a forma como estas variáveis interagem e têm impacto na sustentabilidade da dívida pública num contexto de incertezas económicas, em particular na sequência de crises financeiras e das repercussões atuais da pandemia de COVID-19.

Foi utilizado um conjunto de técnicas quantitativas, começando pelo coeficiente de correlação de Pearson para explorar a natureza das associações entre as variáveis. Posteriormente, foram efetuadas análises de regressão linear para avaliar o impacto das variáveis individuais na dívida pública. Um modelo de mínimos quadrados ordinários (OLS) foi então utilizado para avaliar os efeitos coletivos de todas as variáveis. Foram também considerados modelos de efeitos fixos e aleatórios, com o teste de Hausman a ajudar na determinação do modelo mais adequado.

Os resultados revelam que as despesas sociais e o PIB afetam positivamente a dívida pública, enquanto a inflação apresenta uma correlação negativa com a mesma. Este facto sugere, nomeadamente, que uma inflação moderada pode desempenhar um papel na redução do peso da dívida. Além disso, as taxas de juro das obrigações a 10 anos foram identificadas como fatores significativos que influenciam a dinâmica da dívida pública. De um modo geral, este estudo contribui com informações valiosas sobre as complexidades da dívida pública na Zona Euro e lança as bases para novas investigações sobre relações macroeconómicas semelhantes noutros contextos, apesar de limitações como a exclusão de fatores institucionais específicos. A investigação tem implicações significativas para a formulação de políticas orçamentais sustentáveis numa era caracterizada por níveis crescentes de dívida pública a nível mundial.

Palavras-chave: Dívida Pública, Despesa Social, PIB, Zona Euro, Dados em Painel, Sustentabilidade Fiscal.

Abstract

This dissertation primarily investigates the relationship between public debt (DP), social spending (DS), and the elderly population (PI) in Eurozone countries, while also considering the influence of additional macroeconomic variables, including 10-year bond interest rates (TXj), the savings rate (NSP), and the inflation rate (INF). The analysis delves into how these variables interact and impact the sustainability of public debt amid economic uncertainties, particularly in the wake of financial crises and the ongoing repercussions of the COVID-19 pandemic.

A range of quantitative techniques was employed, starting with Pearson's correlation coefficient to explore the nature of associations among the variables. Subsequently, linear regression analyses were conducted to assess the impact of individual variables on public debt. An Ordinary Least Squares (OLS) model was then utilized to evaluate the collective effects of all variables. Fixed and random effects models were also considered, with the Hausman test aiding in the determination of the most suitable model.

The findings reveal that social spending and GDP positively affect public debt, while inflation displays a negative correlation with it. Notably, this suggests that moderate inflation may play a role in mitigating debt burdens. Furthermore, interest rates on 10-year bonds were identified as significant factors influencing public debt dynamics. Overall, this study contributes valuable insights into the complexities of public debt in the Eurozone and lays the groundwork for further research on similar macroeconomic relationships in other contexts, despite limitations such as the exclusion of specific institutional factors. The research holds significant implications for the formulation of sustainable fiscal policies in an era characterized by rising levels of public debt globally.

Keywords: Public Debt, Social Spending, GDP, Eurozone, Panel Data, Fiscal Sustainability.

Index

Index of figures

Index of tables

Glossary of Acronyms

AT – Austria

BCE – European Central Bank

BE - Belgium

DE - Germany

DP - Public Debt (Debt as a Percentage of GDP)

DS - Social Spending (as a Percentage of GDP)

ECB – European Central Bank

ES - Spain

EZ – Eurozone

FE - Fixed effects

FI - Finland

FR - France

GDP - Gross Domestic Product

GR - Greece

GMM - Generalized Method of Moments

IE – Ireland

IMF – International Monetary Fund

INF - Inflation Rate

IT - Italy

LT - Lithuania

LU - Luxembourg

NL – Netherlands

NSP - Savings Rate

OLS - Ordinary Least Squares

OECD - Organisation for Economic Co-operation and Development

PEPP - Pandemic Emergency Purchase Programme

PI - Elderly Population (as a Percentage of Total Population)

PT - Portugal

RE – Random effects

SI - Slovenia

SK - Slovakia

TXj - 10-Year Government Bond Yield

CHAPTER 1

Introduction

The issue of sustainable public debt represents a pivotal point of contention within the realm of economic policy discourse, particularly within developed economies such as those comprising the eurozone. Here, the challenges inherent to fiscal policy are inextricably linked to demographic dynamics and macroeconomic conditions. In the wake of the global financial crisis of 2008, which was followed by the European sovereign debt crisis, numerous countries have been confronted with the challenge of achieving a balance between the necessity for economic growth and the reduction of public debt. These factors impact the government's capacity to effectively manage its debt over time. In consequence of the European sovereign debt crisis, a few countries within the eurozone have implemented policies designed to prevent an increase in the level of debt. Nevertheless, the efficacy of these measures has been the subject of considerable debate, with some commentators arguing that in certain instances they have the unintended consequence of intensifying recessions, increasing unemployment and reducing tax revenues, thereby creating a vicious cycle of indebtedness. Concurrently, interest rates and inflation are pivotal variables that influence the cost of debt and its dynamics over time. The interrelationship between these factors, including long-term bond interest rates, inflation, domestic savings and social spending, and public debt remains poorly understood in the context of Eurozone countries, particularly in the aftermath of the financial crisis and the pandemic.

1.1. Theoretical Context

In the field of macroeconomics and public finance, public debt is regarded as a pivotal instrument for bridging the fiscal deficit and facilitating investment in infrastructure and other sectors that drive economic growth. Nevertheless, the detrimental impact of persistently elevated levels of public debt on economic growth is evident, particularly when the servicing of debt (interest payments) absorbs a considerable proportion of tax revenues. The extant literature indicates that the relationship between debt and growth is non-linear. Up to a certain point, debt can stimulate growth; however, when debt levels reach high levels, it can have adverse effects on the economy.

A particularly salient factor in the evolution of public debt is demographic change, notably the growth in the elderly population (PI). As the proportion of the population comprising the elderly cohort increases, so too does the demand for public services, such as pensions and healthcare, resulting in an increase in social expenditure. This dynamic exerts pressure on the national budget, thereby increasing the necessity for financing and consequently increasing debt. Furthermore, the shrinking labor force reduces the tax collection base, thereby exacerbating the challenge of debt repayment.

Furthermore, other macroeconomic variables, such as inflation (INF) and 10-year bond yields (TXj), are significant with regard to the sustainability of debt. The research by the International Monetary Fund (IMF) emphasizes that a higher interest rate relative to the growth rate necessitates governments to maintain a primary budget surplus to stabilize debt levels. Conversely, a straightforward increase can diminish the real value of the loan over time, thereby facilitating its administration. Conversely, elevated interest rates raise the cost of borrowing, which can imperil the government's capacity to meet current expenses and investments without accumulating debt. Furthermore, the domestic savings rate (NSP) can constrain the availability of capital to finance the government without recourse to external sources of finance and diminish exposure to external risks and discrepancies in the debt markets.

1.2. Objective of the dissertation

The principal aim of this dissertation is to examine the relationship between public debt (PD) and a set of macroeconomic and demographic variables, specifically the elderly population (PI), social spending (DS), interest rates on 10-year bonds (TXj), and two additional variables, namely the inflation rate (INF) and the domestic savings rate (NSP), in Eurozone countries. The objective of the analysis is to assess the impact of each of these variables on the sustainability of public debt and to identify the primary factors responsible for the growth or reduction of debt over time. To this end, dynamic panel econometric models are employed, which facilitate the capture of the intricate interdependencies between the variables and address the issue of endogeneity, which is frequently encountered in studies of this nature.

1.3. Importance of the topic

The topic addressed in this dissertation is highly relevant today, as many Eurozone countries are facing growing fiscal and structural challenges, exacerbated by an ageing population and uneven economic recovery following the COVID-19 pandemic. With the high levels of public debt observed in several countries, it is essential to understand the determinants of debt sustainability in order to avoid future crises and ensure long-term fiscal viability.

In addition, the global macroeconomic landscape is constantly changing, with inflationary pressures and uncertainties in global financial markets that can increase the cost of debt financing for governments. In this sense, studies exploring the relationship between public debt and macroeconomic factors provide a valuable basis for drawing up public policies, both at national and supranational level.

1.4. Dissertation structure

The dissertation is comprised of four chapters. Chapter 1, entitled "Literature Review," presents the theoretical framework that informs the study. It also reviews existing literature on public debt, fiscal sustainability, and the impact of demographic and macroeconomic variables on debt evolution. Chapter 2, "Methodology," discusses the econometric techniques used. It justifies the use of dynamic panel data models and details the variables and data used. Chapter 3, entitled "Analysis of Results," presents the empirical results of the econometric estimations. It analyses how each variable affects public debt and assesses the robustness of the results. Finally, Chapter 4, entitled "Conclusion," summarizes the main conclusions and results of this dissertation. It also presents the limitations of the study and suggests solutions for possible future research.

It is anticipated that this structure will facilitate the contribution of the dissertation to the ongoing debate on public debt sustainability, providing new empirical evidence and offering insights that are relevant to the formulation of effective economic policies. This dissertation makes a significant contribution to the existing literature on the relationship between demographic change, public debt and macroeconomic variables within the context of the Eurozone. The study examines the impact of an ageing population on the sustainability of public finance, taking into account factors such as social spending, inflation and bond yields. The research employs empirical data and rigorous analytical techniques to underscore the necessity of adapting fiscal policies to accommodate demographic shifts. Furthermore, this work emphasizes the role of the European Central Bank's monetary policies in the management of public debt, thereby providing a comprehensive understanding of the current economic landscape and future challenges.

CHAPTER 2

Theoretical framework and literature review

The impact of demographic evolution on public debt rates in the Eurozone is a topic of crucial relevance in the current global economic panorama. As populations age and demographic dynamics undergo substantial transformations, Social Security, and health systems and, consequently, public finances face significant challenges.

2.1 Theories of change in demographic composition and their influence on public debt rates in the Eurozone

The correlation between demographic shifts and public debt is intricate and multifaceted, serving as a focal point in various economic doctrines. Within this survey of literature, we will delve into some of the primary theories that shed light on how alterations in demographic structures can impact public debt levels in the Eurozone.

2.1.1. Theory of Life Cycle

The life cycle theory, formulated by Franco Modigliani and Richard Brumberg, posits that individuals meticulously plan their financial strategies over their lifetimes, weighing current and future expenditures against their anticipated earnings. As per Modigliani and Brumberg (1954), "*consumer behavior is influenced by demographic variables like age, marital status, and household composition, which mold their consumption needs and preferences*".

In the public debt scenario, this theory implies that an aging population may drive up the need for public services like healthcare and social security as more individuals reach retirement age. This may strain government finances, leading to budget deficits that are commonly offset through public borrowing. According to Modigliani and Brumberg (1980), "*the aging population poses significant challenges to public finances, particularly in state-sponsored welfare systems*." Moreover, life cycle theory suggests that people can bolster their savings in their working years to fund their retirement expenses. However, this extra saving might not suffice to meet the escalating costs linked with an aging population, especially in cases where social security systems fall short. According to Hurd and Rohwedder (2013), the rise in pension and healthcare expenditures resulting from population aging may put pressure on public finances, causing a growth in government debt.

Therefore, the life cycle theory provides valuable perspectives on how demographic shifts can impact public debt levels in the Eurozone, emphasizing the necessity of implementing policies to tackle the financial difficulties linked to an aging society.

Keynes' Life Cycle Theory emphasizes the significance of saving at some stage in lifestyles to hold intake stable, particularly at some point of retirement. Keynes argues that people keep at some point of their operating years to finance intake at some point of retirement, which means that financial savings behavior is without delay related to the lifestyles cycle.

2.1.2.Theory of Rational Expectations

The theory of Rational Expectations, primarily associated with Robert Lucas Jr. and other economists, emphasizes the role of economic agents' expectations in influencing macroeconomic factors. According to this theory, agents formulate their expectations based on all available information, including historical data and government policies.

In the context of public debt, Rational Expectations suggests that agents' anticipations regarding demographic changes and future fiscal strategies can affect interest rates on government debt. If economic agents foresee demographic shifts—such as an aging population leading to increased fiscal pressures—they may demand higher risk premiums to compensate for the perceived rise in credit risk associated with public debt.

Furthermore, the theory highlights the importance of credibility and consistency in fiscal policies for shaping agents' expectations. Blanchard (1985) in "Debt, Deficits, and Finite Horizons" argues that unreliable fiscal measures or inconsistencies can undermine investor confidence, resulting in elevated interest rates on government debt.

Consequently, Rational Expectations underscores the necessity for transparency and reliability in fiscal policies to maintain stable interest rates on public debt. Against the backdrop of demographic changes in the Eurozone, this theory stresses the need for coherent and sustainable fiscal measures that align with economic agents' expectations to foster credibility and financial stability.

Mankiw (2001) in "Macroeconomics (5th ed.)" explores the implications of rational expectations in macroeconomic models, emphasizing how agents' anticipations influence economic outcomes, including fiscal policies and debt sustainability.

Additionally, Sargent (1993) in "Bounded Rationality in Macroeconomics" delves into the relationship between rational expectations and monetary policy, highlighting how the credibility of government actions affects economic agents' forecasts and, consequently, interest rates on public debt.

Lucas (1976) in "Econometric Policy Evaluation: A Critique" also provides foundational insights into the theory, examining how expectations shape policy effectiveness and public debt dynamics.

2.1.3. The theory of fiscal sustainability (Blanchard, 1990)

This theory examines the relationship between public debt and economic growth, discussing the conditions under which public debt is sustainable in the long term. A government can be considered fiscally sustainable when it is able to honor its debt obligations without continuously increasing the debt-to-GDP ratio. The theory identifies economic growth and interest rates as key variables, as they determine whether the debt can be stabilized or reduced over time.

In the context of the Eurozone, the theory of fiscal sustainability is central to understanding how population ageing (PI), which puts pressure on social spending (DS), can make public debt (DP) management more difficult, especially in a context of more volatile interest rates (TXj). The study considers how these factors can impact on countries' ability to keep their debt at sustainable levels.

2.1.4. Endogenous Growth Theory (Romer, 1986; Lucas, 1988)

This theory posits that long-term economic growth is driven by internal factors, including investment in human capital, technological innovation, and the implementation of appropriate economic policies. This approach posits that economic growth is a crucial means of financing social spending (DS) and reducing reliance on public debt (DP).The endogenous growth theory is pertinent to the analysis of the sustainability of public debt in the context of population ageing (PI) due to its focus on economic growth as a key driver of long-term growth. As growth increases, government revenue rises, thereby facilitating the coverage of social spending without an excessive expansion of public debt.

2.1.5. Keynesian Theory of Public Finance

John Maynard Keynes posited that during periods of economic downturn, governments should augment public expenditure as a means of stimulating economic activity, even if this entails an increase in public debt in the near term. This theory posits that governments can utilize budget deficits as a means of

stabilizing the economy. However, this approach necessitates a meticulous equilibrium to avert an unsustainable escalation of debt over the long term.

The active fiscal policy recommended by Keynesian theory is exemplified by the Eurozone's responses to economic crises, particularly during the period under analysis (2012-2021). During this period, several countries increased spending in order to mitigate the effects of the 2008 financial crisis and the sovereign debt crisis. Nevertheless, this results in an increase in public debt (DP), while population ageing (PI) exerts further pressure on social spending (DS).

2.1.6. Ricardian Equivalence Hypothesis (Ricardo, 1820; Barro, 1974)

The argument put forth by this theory is that budget deficits financed by public debt do not affect the level of aggregate demand in the economy. This is because economic agents anticipate that the increase

in public debt will result in future tax increases. Consequently, individuals increase their current savings in order to compensate for this effect.

The Ricardian equivalence concept can be discussed in terms of its impact on future expectations, particularly in relation to population ageing (PI). If citizens anticipate that an increase in social spending will result in an increase in public debt, they may adjust their consumption and savings behavior, which could affect the general economic dynamic.

2.1.7.Laffer Curve Theory

The theory posits that there exists an equilibrium point in taxation, whereby government revenue is optimized. If the tax rate is set at an excessively high level, the motivation to engage in work and investment activities is diminished, which ultimately results in a reduction in tax revenue.

As the population ages, there may be an increased pressure to raise taxes in order to finance social spending. However, the Laffer curve theory cautions against the potential risks of increasing taxes to the point of deterring economic growth, which could exacerbate the public debt issue.

These theories provide a robust theoretical foundation for elucidating the interrelationships between the variables in the thesis (DP, DS, PI and TXj) and the pivotal role of efficacious economic policies in the management of public debt in the context of substantial demographic transformation.

2.2 History on the Impact of Demographic Change on Public Debt Rates in the Eurozone

Understanding the effect of demographic evolution on public debt fees withinside the Eurozone calls for an ancient evaluation to contextualize the modifications over time. This evaluation highlights the primary demographic and financial occasions and developments which have formed the connection among demographics and public debt withinside the place.

2.2.1.Demographic developments in the eurozone

Analyzing demographic trends in the Eurozone is crucial for understanding how changes in population structure affect public finances and, consequently, public debt dynamics in the region. This section explores the key aspects of demographic evolution within the Eurozone and its fiscal implications.

Demographic evolution in the Eurozone is pivotal in grasping shifts in population structure over time. Authors such as Jacques Poot and Jan de Haan in “Migration and Human Capital” (2018) underscore the importance of migration and human capital in shaping the Eurozone’s population dynamics. Their work examines migration patterns and their effects on population growth and distribution, illustrating how migration serves as a key factor in offsetting the demographic pressures of an aging population.

Further, Ronald Lee and Andrew Mason in "Population Aging and the Generational Economy: A Global Perspective" (2011) delve into key demographic trends such as population aging. They highlight how rising life expectancy and declining fertility rates contribute to an increasing proportion of older individuals relative to the working-age population. This shift presents significant challenges for the Eurozone, as it leads to heightened fiscal pressure from pensions and healthcare spending, affecting long-term economic stability.

The economic consequences of population aging are further explored by Axel Börsch-Supan and Karsten Hank in "Ageing, Social Security, and the Demographic Dividend Hypothesis: How Does Population Aging Really Affect the Economy?" (2020). They analyze how the growing costs associated with aging, particularly in social security and healthcare, place significant strain on public budgets and challenge the fiscal sustainability of Eurozone economies.

Finally, Martin Werding in "Demographic Change, Fiscal Policy and Economic Growth: Implications for the Netherlands and Other Industrial Countries" (2016) addresses the public policies needed to tackle demographic shifts in the Eurozone. Werding discusses the critical role of pension reform and immigration policies in mitigating the challenges posed by an aging population, offering policy solutions aimed at enhancing long-term fiscal sustainability in the face of demographic change.

2.2.2.Economic and Political Trends

Over the past few decades, the Eurozone has experienced several economic and political crises that have significantly impacted public finances and sovereign debt levels. The global financial crisis of 2008 and the subsequent sovereign debt crisis in the Eurozone highlighted the critical importance of maintaining fiscal sustainability and prudently managing public debt.

In order to fully comprehend the economic and political dynamics in the Eurozone and their relationship to public debt rates, it is essential to examine the perspectives of various economists and the policies implemented over time. Paul Krugman in "End This Depression Now!" and Joseph Stiglitz in "The Euro: How a Common Currency Threatens the Future of Europe" argue that the Eurozone faces major challenges due to the lack of economic convergence among its members and the rigidity of fiscal and monetary policies. In their works, Krugman (2013) and Stiglitz (2016) emphasize the need for more flexible policy frameworks and greater coordination among member states to promote economic growth and reduce disparities within the Eurozone.

Authors such as Olivier Blanchard and Mario Draghi highlight the importance of appropriate fiscal and monetary policies to stabilize the Eurozone economy. Draghi, in "*Unemployment in the euro area* [Speech]" and publications, has strongly advocated for expansionary policies (a set of economic measures implemented by governments or central banks to stimulate economic growth) implemented by the European Central Bank (ECB), particularly following the 2008 crisis, to counter economic

stagnation and reduce public debt burdens. Blanchard (2019) in “Public Debt and Low Interest Rates” stresses the necessity of adopting more adaptable fiscal policies to address asymmetric shocks and promote macroeconomic stability, underscoring the significance of countercyclical measures within the Eurozone's policy framework.

Carmen Reinhart and Kenneth Rogoff in “Growth in a Time of Debt” contribute to the debate by arguing that structural reforms, such as improving labor market flexibility and boosting competitiveness, are essential for fostering economic growth and reducing fiscal pressures (*Reinhart & Rogoff, 2010*). However, their view is met with some contention, as there is ongoing debate about the potential adverse effects of such reforms on income inequality and social safety nets.

From a political and institutional perspective, figures like Jean-Claude Trichet in “Central Banking in the Euro Area” and Christine Lagarde in “Building a More Resilient and Inclusive Global Economy” underline the significant political challenges facing the Eurozone. In their writings, they emphasize the need for deeper political and fiscal integration among member states to effectively address these crises (*Trichet, 2012; Lagarde, 2017*). They contend that a lack of political cohesion has hindered the ability to implement effective policies to manage the debt crisis and secure long-term stability in the region.

2.2.3.Impact on Public Debt

The aging population and changing demographic structure have significant implications for public finances, especially concerning sovereign debt. Increased spending on social security and healthcare, driven by an aging population, exerts pressure on government budgets and can contribute to a rise in public debt. Additionally, the shrinking labor force relative to the working-age population impacts economic growth and the government's ability to generate tax revenues.

Blanchard and Leigh (2013) in “Growth Forecast Errors and Fiscal Multipliers” highlight the importance of considering uncertainty around growth projections when assessing the effects of fiscal policies, particularly those related to public debt. They argue that economic growth forecasts often underestimate the significance of fiscal multipliers, which can lead to misinformed policy decisions and increase the risk of rising public debt.

On the other hand, Elmendorf and Sheiner (2000) in “Should America Save for its Old Age? Fiscal Policy, Population Aging, and National Saving” examine the economic challenges associated with an aging population in the U.S. and its potential impact on public debt. Their research emphasizes the need for policies that encourage national savings and address rising social security spending to prevent unsustainable debt growth. Favero and Giavazzi (2007) in “Debt and the Effects of Fiscal Policy” investigate the effects of public debt and fiscal policies within the European context, with a focus on aging populations. They underscore the importance of prudent and sustainable fiscal policies to maintain

macroeconomic stability and avoid sovereign debt crises in an environment where demographic changes are creating new fiscal pressures.

2.2.4. Future Challenges

In analyzing demographic evolution within the Eurozone and its associated challenges, it is crucial to engage with the insights of leading scholars and researchers. In their work, George A. Akerlof and Rachel E. Kranton (2010), in "Identity Economics: How Our Identities Shape Our Work, Wages, and Well-Being", highlight the importance of sustainable economic policies in addressing demographic challenges. They argue that changes in demographic structures, particularly related to aging, place significant pressures on pension and healthcare systems, thereby necessitating economic reforms to ensure long-term sustainability and resilience within the Eurozone. Similarly, Richard B. Freeman and Ronald Schettkat (2005), in their study "Marketization of Production and the US-Europe Employment Gap", underscore the impact of demographic change on labor markets and productivity. They focus on how aging populations influence labor market dynamics and emphasize the need for policies that encourage employment, innovation, and productivity to counteract potential economic slowdowns associated with a shrinking workforce.

Furthermore, Thomas Piketty (2014), in "Capital in the Twenty-First Century", addresses issues of inequality and social inclusion that arise from demographic changes within the Eurozone. Piketty argues that an aging population can exacerbate income and wealth disparities, particularly as older generations tend to accumulate more wealth over time. However, it's important to note that not all elderly individuals are wealthy. There are significant portions of the older population who live in poverty, especially those who did not have access to high-paying jobs, pensions, or other forms of long-term wealth accumulation. He stresses the importance of redistributive policies and social inclusion measures to mitigate these inequities and foster long-term social cohesion. Moreover, Philippe Aghion and Peter Howitt (2009), in "The Economics of Growth", examine the crucial role of innovation and competitiveness in tackling demographic challenges. They assert that investments in research, development, and education are vital to boosting economic growth and enhancing the Eurozone's competitiveness, particularly as the region contends with an aging workforce. According to Aghion and Howitt, policies aimed at enhancing human capital and fostering innovation are fundamental to ensuring the Eurozone's economic sustainability in the face of demographic shifts.

2.3 Causes of Demographic Change and Their Impact on Public Debt Rates in the Eurozone

In order to evaluate the reasons for demographic shifts and their impact on public debt within the Eurozone, it is necessary to conduct a comprehensive review of the existing literature on the subject.

In relation to the ageing population, the study conducted by Wolfgang Lutz and colleagues in "Demographic Metabolism" in their 1997 article, "A Predictive Theory of Socioeconomic Change," the authors identify population aging as a primary driver of demographic change within the Eurozone. An increase in life expectancy and a decline in birth rates contribute to population ageing, which could have significant implications for public finances, including higher spending on social security and healthcare.

With regard to the topic of migration and population diversity, the author Sergio Della Pergola, in the work "Jewish Demographic Policies: In his 2000 publication, Population Trends and Options in Israel" and with the Diaspora, Sergio Della Pergola elucidates the role of migration and population growth in demographic evolution. Migration can have a significant impact on the age structure and demographic composition of the Eurozone, which in turn affects public finances through its influence on the labor market, tax revenue and social welfare systems.

With regard to fertility and birth rates, Tomas Sobotka et al. (2010) examine the future of fertility in Europe in their article, 'The Future of Fertility in Europe'. In their 2011 study, "Exploring the Influence of Circumstances, Policies, and Values," the authors examine fertility trends and birth rates within the Eurozone. Transformations in family preferences, access to contraception, and work-family balance policies can influence birth rates, thereby affecting demographic dynamics and long-term projections for public finances.

Additionally, the authors Ronald Lee and Andrew Mason, in "Population Aging and the Generational Economy: In A Global Perspective" (2011), the authors examine the impact of demographic and social regulations on demographic and economic trends. Policies designed to encourage higher birth rates, boost labor force participation, and reform pension structures should be implemented.

2.3.1.The impact of population aging on public debt

The impact of an aging population on public debt has emerged as a significant concern, particularly in advanced economies where demographic shifts towards older populations exert increasing pressure on government finances. As life expectancy rises and birth rates decline, countries face the challenge of financing an expanding social security system, which may lead to a heightened public debt burden.

Thus, it is essential to understand the interrelationship between population aging and the long-term sustainability of fiscal policies, particularly within the context of the Eurozone, where this demographic shift poses substantial challenges. The following empirical studies provide valuable insights into the dynamics of aging populations and their implications for public debt and fiscal sustainability.

Several empirical studies have investigated the effects of population aging on public debt and fiscal sustainability, highlighting the difficulties governments face due to an aging populace. Razin, Sadka, and Swagel (2002) in “The aging population and the financial sustainability of the welfare state” explore the impact of population aging on the structure and financial pressures of welfare states. Their study reveals that an aging population leads to increased expenditures on welfare, particularly pensions and healthcare, which in turn contributes to a rise in public debt. This research is particularly relevant for examining the interrelationship between demographic shifts and fiscal policies in welfare-oriented economies, such as those within the Eurozone.

In a further development of this inquiry, Kamiguchi and Tamai (2019) in “Population Aging and Public Investment: An Analysis of the Golden Rule of Public Finance” investigate the impact of an aging population on public investment and debt within the framework of the 'golden rule' of public finance, which seeks to maintain a balance between public investment and debt sustainability. They argue that while public investment is crucial for economic growth, aging populations impose additional fiscal pressures on economies, thereby increasing the risk of debt unsustainability. These findings are particularly pertinent to countries like Italy and Greece, where demographic changes exacerbate existing fiscal imbalances.

Lastly, Prammer (2019) in “Aging and Public Finances: A Long-term Perspective” analyzes the impact of an aging population on tax revenues and social security contributions. As the proportion of the working-age population declines and demand for social services rises, governments confront a shrinking tax base coupled with the challenge of financing escalating social expenditures. Prammer's empirical evidence highlights the fiscal strain induced by demographic changes, making it highly relevant for understanding long-term debt dynamics in the Eurozone.

CHAPTER 3

Methodology and data

The database employed encompasses a temporal scope of analysis from 2012 to 2021, with the exception of Cyprus, Malta, Estonia, and Latvia, which are excluded due to the unavailability of some variables from these countries. The rationale for this exclusion and the selected analysis period will be elucidated in the section entitled "Presentation and Analysis of Results."

Table 1– Descriptive table of the variables used in the study.

Statistical variables/series	Description	Data source	Periodicity of data	Period of time
Demographics	Percentage of elderly population	Eurostat OECD Pordata	Annual	From 2012 to 2021
Economic	Economic indicators – GDP and inflation	Eurostat OECD Pordata	Annual	
Public finances	Public debt, social expenses and	Eurostat OECD	Annual	
Interest Rates	Interest rates on public bonds	Eurostat OECD	Annual	

The data were structured in panel data format, which was an appropriate methodological choice as it increases the accuracy of the estimates by controlling for unobservable factors that are specific to each country and do not vary over time. The relationship between the four variables was explored using a rigorous and varied approach to statistical techniques, including Pearson's correlation and simple regressions. To initially ascertain the correlations between these variables, Pearson's correlation was employed, which facilitates the identification of the strength and direction of the associations between them. Simple regressions were also conducted to isolate the relationship between each independent variable and PD, before progressing to more complex models, such as the OLS model.

The econometric methodology is founded upon four principal approaches: the OLS Model, the Fixed Effects Model, the Random Effects Model and the Arellano-Bond/GMM Dynamic Model. The initial model was estimated using the ordinary least squares (OLS) method to gain insight into the relationships between the dependent and independent variables.

In order to address the potential influence of unobservable heterogeneities on the results, fixed and random effects models were estimated. In addition to the conventional models, the dissertation employs the Dynamic Arellano-Bond/GMM model, which is well-suited to addressing potential endogeneity

issues, particularly in instances where there is a significant temporal dependency, such as when the probability of default in a given year directly influences the probability of default in the subsequent year.

In order to select the most appropriate model for the database in question, the Hausman test was employed to ascertain whether the coefficients estimated by the two models are significantly different. The selection of panel data models, the Hausman test and the Arellano-Bond/GMM Dynamic Model was driven by the necessity to address potential endogeneity issues and unobservable variables that fluctuate across countries but remain constant over time.

In terms of the theoretical aspects covered, several topics pertinent to this dissertation were addressed, including the implications of economic growth, the European Central Bank's monetary policies, the impact of life expectancy, measures and policies adopted by Eurozone countries, solutions for the demographic impact on private debt interest rates and other relevant indicators such as the level of inflation and the level of domestic savings, and the interrelationships between the variables and public debt.

CHAPTER 4

Presentation and analysis of results

The data set under examination in this dissertation was transformed into panel data due to the fact that the database contains both temporal and cross-sectional information, thereby enabling the analysis of several countries over time. In this instance, the interaction between public debt and other economic indicators is the subject of analysis. The decision to construct a database spanning the period between 2012 and 2021 is contingent upon the availability of consistent data for the four key variables. The variables of interest are public debt, social expenditure, the elderly population and 10-year bond interest rates. This choice guarantees greater consistency and comparability of the results. Conversely, countries such as Cyprus, Malta, Estonia and Latvia, which are part of the Eurozone and the focus of this dissertation, were excluded due to the unavailability of the TXj variable for these specific economies.

4.1. Description of the economic context: the evolution of social spending, the elderly population, public debt and 10-Year Government Bond Yield

4.1.1. Variable DS

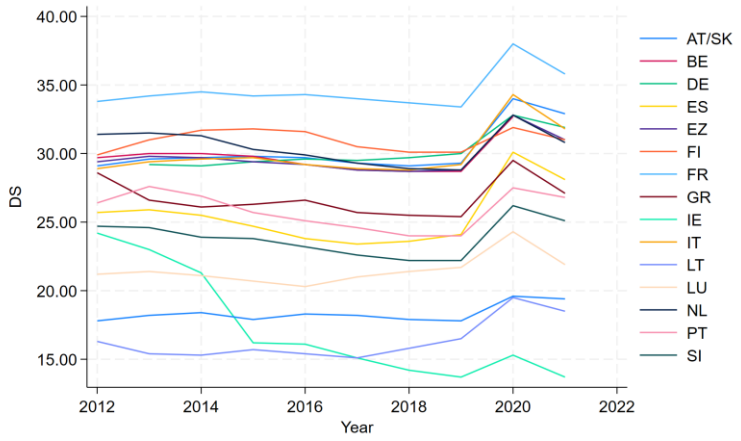


Figure 1 - The evolution of social spending between 2012 and 2021 in Eurozone

Source: Stata; Eurostat; OECD

The proportion of gross domestic product (GDP) allocated to social services varies (such as social security payments, healthcare expenditures, unemployment benefits, family benefits, housing assistance) between countries. Nations such as France, Finland and Austria have a relatively high percentage of GDP allocated to social services, which reflects a strong commitment to social welfare. Conversely, countries such as Ireland and Lithuania exhibit lower levels of social spending, which may be indicative of a more constrained role for the state. In the Eurozone, social spending increased from 29.4% to 31.0% between 2012 and 2021. There was a peak of 32.8% in 2020 due to the impact of the

global pandemic, which resulted in an increase in public debt to 97.3% of GDP. One of the principal causes of this increase is population ageing. There are also concerns about the long-term sustainability of public finances, particularly in the absence of significant reforms in the areas of pensions and health.

4.1.2. Variable PI

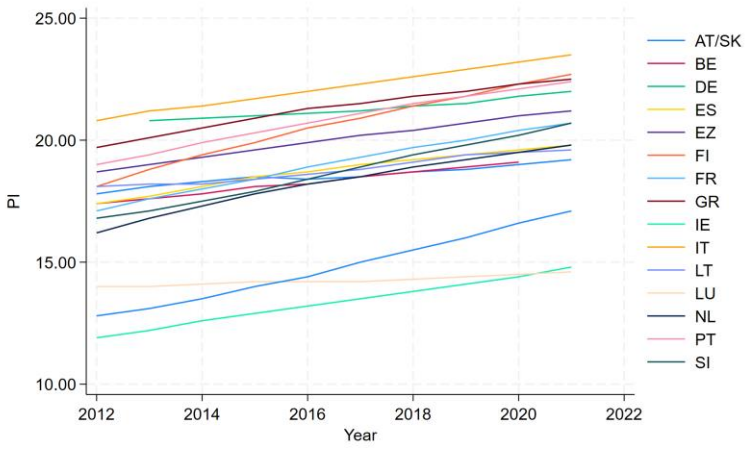


Figure 2 - The evolution of the elderly population between 2012 and 2021 in Eurozone

Source: Stata; Eurostat; OECD

The growth in the elderly population (refers to individuals who are aged 65 and older) in countries such as Italy, Greece, Germany and Finland present a significant challenge for the financing of pensions and healthcare, exerting considerable pressure on public finances. Conversely, countries with younger populations, such as Ireland and Luxembourg, are less immediately constrained. Between 2012 and 2021, the proportion of the population in the Eurozone that was elderly increased from 18.7% to 21.2%. This was accompanied by a significant increase in public debt, particularly in 2020 due to the pandemic, when debt reached 97.3% of GDP.

Furthermore, countries such as Greece and Italy, which have a high proportion of elderly people, also have high levels of public debt. This reflects the impact of rising spending on pensions and healthcare. These expenses have been financed primarily through public debt, which has been further exacerbated by the shrinking base of active workers.

4.1.3. Variable DP

The ratio of public debt to gross domestic product (GDP) is a crucial indicator of a country's fiscal sustainability and debt burden. Countries with high proportions of public debt are confronted with considerable fiscal challenges, potentially resulting from previous economic crises or expansionary fiscal policies. Examples of such countries include Greece (186.40%), Italy (134.50%), Portugal (121.50%), and Belgium (99.90%) in 2018. However, there are countries that have greater fiscal control and a more stable economic position, resulting in low public debt figures. These include: The countries

with the lowest levels of public debt are Luxembourg (20.90%), the Netherlands (52.40%), Germany (61.90%) and Finland (64.80%) in 2018.

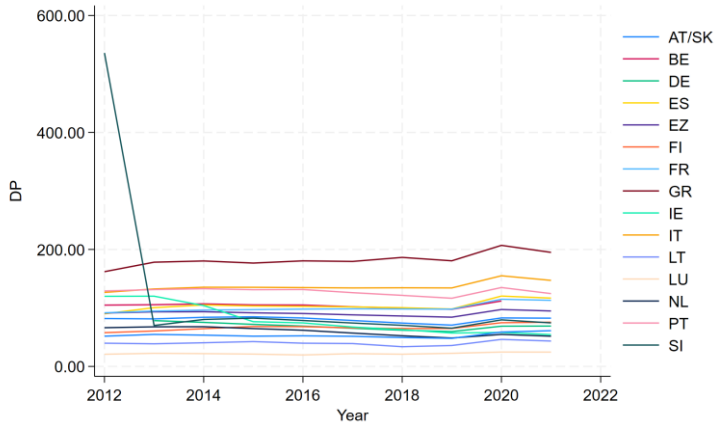


Figure 3 - The evolution of public debt between 2012 and 2021 in Eurozone

Source: Stata; Eurostat; OECD

4.1.4. Variable TXj

Bond interest rates serve as a barometer for the government's cost of financing, and, in turn, provide insight into the risk perception associated with the country in question. The interest rates in Greece, Portugal and Italy are notably high, at 4.19%, 1.84% and 2.61% respectively, in 2018. These elevated rates reflect a heightened credit risk and more pronounced economic challenges, which in turn increase the cost of servicing the debt and constrain the fiscal space available for other policies. Conversely, in 2018, Germany (0.09%), France (0.78%), Finland (0.66%) and the Netherlands (0.58%) have lower interest rates, which reflect the high level of confidence that investors have in these countries with regard to their capacity to service their debts.

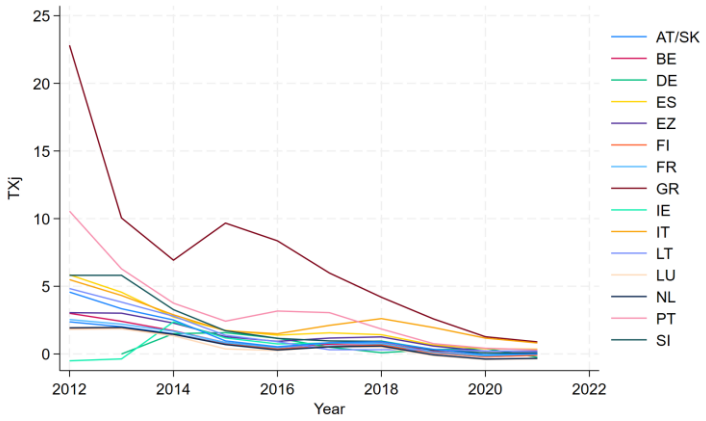


Figure 4 - The evolution of 10-Year Government Bond Yield between 2012 and 2021 in Eurozone

Source: Stata; Eurostat; OECD

The ageing of the population has the effect of reducing the active labor force, which in turn has the consequence of decreasing tax revenues. In the event of an increase in expenditure on health and pensions without a corresponding expansion of the tax base, governments may be compelled to resort to public debt, which has the potential to raise interest spreads due to the risk perceived by investors. Those countries with high levels of debt and ageing populations, such as Italy and Greece, are subject to increased pressure with regard to public debt interest rates. Conversely, Germany, despite also experiencing an ageing population, has been able to maintain lower interest spreads as a result of a robust fiscal policy and pension reforms.

4.2. Descriptive statistics

Table 2 - Descriptive statistics for the DP, DS, PI and TXj variables

Variable	Obs	Mean	Std. dev.	Min	Max
DS	160	26.32688	5.543842	13.7	38
DP	160	89.9475	52.93709	19.6	536
PI	160	18.67312	2.666558	11.9	23.5
TXj	160	1.704437	2.605954	-.51	22.81

Source: Stata

A statistical analysis of the variables reveals that the mean social spending (DS) across the countries is 26.32% of GDP, with a standard deviation of 5.54%. This indicates a notable degree of variation in social spending. The mean value of public debt (DP) is 89.95% of GDP, with a high degree of variability (standard deviation of 52.94%) and a wide range, from 19.6% to 536%, which reflects the inequality in debt burdens between countries. The proportion of the population that is elderly (PI) has an average of 18.67 per cent, with a moderate degree of variation between countries (standard deviation of 2.67 per cent). The mean interest rate for 10-year bonds is 1.70%, with considerable variation (standard deviation of 2.67%) and a range of -0.51% to 22.81%. This reflects disparities in economic conditions and monetary policies across countries.

4.3. Relationships between the 4 variables

4.3.1. Pearson's correlation

Pearson's correlation is a statistical measure that assesses the strength and direction of the linear relationship between two quantitative variables. The Pearson correlation coefficient varies between -1 and 1. A value of +1 indicates a perfect positive correlation, a value of -1 indicates a perfect negative correlation, and a value of 0 indicates no linear correlation. This metric is useful for determining whether

a relationship exists between two variables and, if so, the strength of that relationship. The relationship between the four variables is calculated as follows:

$$r_{DP,DS} = \frac{\sum(DP_i - \overline{DP})(DS_i - \overline{DS})}{\sqrt{\sum(DP_i - \overline{DP})^2 \sum(DS_i - \overline{DS})^2}} \quad (4.1) \qquad r_{DP,PI} = \frac{\sum(DP_i - \overline{DP})(PI_i - \overline{PI})}{\sqrt{\sum(DP_i - \overline{DP})^2 \sum(PI_i - \overline{PI})^2}} \quad (4.2)$$

$$r_{DP,TXj} = \frac{\sum(DP_i - \overline{DP})(TXj_i - \overline{TXJ})}{\sqrt{\sum(DP_i - \overline{DP})^2 \sum(TXj_i - \overline{TXJ})^2}} \quad (4.3)$$

where DP_i, DS_i, PI_i, TXj_i are the values of the variables, $\overline{DP}$, $\overline{DS}$, $\overline{PI}$ e $\overline{TXJ}$ are the averages of the variables DP, DS, PI e TXj e $r_{DP,DS}$, $r_{DP,TXj}$ e $r_{DP,PI}$ is the Pearson correlation coefficient between DP e DS, DP e PI, DP TXj.

Table 3 - Pearson's correlation of the variables DP, DS, PI and TXj

(obs=160)

	DP	PI	DS	TXj
DP	1.0000			
PI	0.3615	1.0000		
DS	0.2792	0.5740	1.0000	
TXj	0.4109	0.0787	-0.0203	1.0000

Source: Stata

Pearson's correlation was employed to examine the interrelationship between economic variables, including social spending (equation 4.1), the elderly population (equation 4.2), public debt (DP), and interest rates (equation 4.3). A moderate positive correlation (coefficient of 0.5740) was observed between SD and PI, indicating that an increase in the elderly population tends to result in an increase in social spending. The correlation between DS and DP is positive but weak (0.2792), indicating that although a relationship exists, other factors also influence public debt. The relationship between social spending and interest rates is practically non-existent, with a correlation coefficient of -0.0203. This indicates that changes in social spending do not have a linear impact on interest rates.

A moderate positive correlation was observed between PI and DP (0.3615), indicating that an increase in the elderly population is linked to growth in public debt, potentially due to higher spending on health and pensions. The relationship between PI and TXj is notably weak, indicating the absence of a significant linear relationship between the elderly population and interest rates. Finally, the correlation between DP and TXj is moderate (0.4109), suggesting that as public debt increases, interest rates also tend to rise due to the greater risk perceived by investors. The opposite can also occur: higher interest rate increases DP

4.3.2. Simple Regression

Simple regressions are a powerful statistical tool that is employed to elucidate the relationship between a dependent variable and an independent variable. This tool enables us to analyse the manner in which public debt responds to variations in three different independent variables: social expenditure, the elderly population and 10-year bond interest rates.

The simple linear regression formula for each combination is as follows:

$$The\ regression\ of\ DP\ in\ DS: DP = \beta_0 + \beta_1 DS + \epsilon \qquad (4.4)$$

$$The\ regression\ of\ DP\ in\ PI: DP = \beta_0 + \beta_1 PI + \epsilon \qquad (4.5)$$

$$The\ regression\ of\ DP\ in\ TXj: DP = \beta_0 + \beta_1 TXj + \epsilon \qquad (4.6)$$

where DP is the dependent variable, DS, PI and TXj are the independent variables, β_0 is the intercept, β_1 is the coefficient of the independent variable, which measures the impact of variable X on DP, ϵ is the error term.

Tables 4, 5 and 6 - The regression of DP in DS, PI and TXj, respectively

Source	SS	df	MS	Number of obs	=	160
				F(1, 158)	=	13.36
Model	34731.1484	1	34731.1484	Prob > F	=	0.0003
Residual	410840.191	158	2600.25437	R-squared	=	0.0779
				Adj R-squared	=	0.0721
Total	445571.339	159	2802.33547	Root MSE	=	50.993

DP	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
DS	2.665939	.7294551	3.65	0.000	1.225198	4.10668
_cons	19.76166	19.62284	1.01	0.315	-18.99525	58.51856

Source	SS	df	MS	Number of obs	=	160
				F(1, 158)	=	23.75
Model	58229.2674	1	58229.2674	Prob > F	=	0.0000
Residual	387342.072	158	2451.5321	R-squared	=	0.1307
				Adj R-squared	=	0.1252
Total	445571.339	159	2802.33547	Root MSE	=	49.513

DP	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
PI	7.176639	1.472547	4.87	0.000	4.268222	10.08505
_cons	-44.06277	27.77427	-1.59	0.115	-98.91952	10.79397

Source	SS	df	MS	Number of obs	=	160
				F(1, 158)	=	32.10
Model	75243.9553	1	75243.9553	Prob > F	=	0.0000
Residual	370327.384	158	2343.8442	R-squared	=	0.1689
				Adj R-squared	=	0.1636
Total	445571.339	159	2802.33547	Root MSE	=	48.413

DP	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
TXj	8.347769	1.473326	5.67	0.000	5.437814	11.25772
_cons	75.71925	4.577676	16.54	0.000	66.67792	84.76058

Source: Stata

Linear regression analysis shows that social spending (DS) in equation 4.4, the proportion of the elderly population (PI) in equation 4.5, and interest rates (TXj) in equation 4.6 have a statistically significant impact on public debt (DP). For each additional unit of DS, public debt increases by an average of 2.66 pp, with a p-value of 0.000, indicating a significant relationship, but the R-squared of 0.0779 reveals that only 7.79 per cent of the variation in DS is explained by DS. In relation to PI, for each additional unit in the proportion of elderly people, public debt increases by an average of 7.177 pp, also with a

p-value of 0.000 and an R-squared of 0.1307. This indicates a stronger relationship between PI and DP, but still suggests the presence of other important factors. The interest rate on 10-year bonds (TXj) has the greatest individual impact on DP, with an increase of 8.347 pp in public debt for each additional unit in TXj, and an R-squared of 0.1689, explaining around 16.89 per cent of the variation in public debt. The result of TXj cannot be interpreted as causality of TXj to DP because DP can also affect TXj, so this result should be interpreted as correlation.

These results highlight the importance of DS, PI and TXj in increasing public debt, but also show that other significant factors were not included in the model.

4.4. Econometric models

4.4.1. OLS model

The Ordinary Least Squares (OLS) model estimated below in figure 10 provides a first insight into the relationship between the independent variables (DS, PI and TXj) and the dependent variable (DP). This model is calculated for the 4 variables as follows:

$$DP = \beta_0 + \beta_1 DS + \beta_2 PI + \beta_3 TXj + \epsilon \quad (4.7)$$

Table 7 - The Ordinary Least Squares (OLS) model for the DP, DS, PI and TXj variables

Source	SS	df	MS	Number of obs	=	160
				F(3, 156)	=	21.44
Model	130099.047	3	43366.3489	Prob > F	=	0.0000
Residual	315472.292	156	2022.25828	R-squared	=	0.2920
				Adj R-squared	=	0.2784
Total	445571.339	159	2802.33547	Root MSE	=	44.97

DP	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
DS	1.388566	.7881724	1.76	0.080	-.1683015	2.945433
PI	4.903219	1.643389	2.98	0.003	1.657053	8.149385
TXj	8.012928	1.37722	5.82	0.000	5.292522	10.73333
_cons	-51.82505	25.43234	-2.04	0.043	-102.0612	-1.588865

Source: Stata

The regression model, calculated by equation 4.7, indicates that an increase of 1 pp in the proportion of the elderly population (PI) is associated with an increase of 4.90 pp in public debt (DP), and this relationship is statistically significant. Social spending (DS) increases public debt by 1.39 pp for every extra unit, with significance close to 10 per cent. Interest rates on 10-year bonds (TXj) have the greatest impact, increasing public debt by 8.01 pp for each additional unit, with high significance.

The R-squared of 29.20 per cent indicates that the model explains around 29 per cent of the variation in public debt, suggesting that other factors not considered influence debt. The OLS model has limitations in that it does not capture country-specific characteristics and correlations that can bias the results.

4.4.2.Random/Fixed Effects Models

- Fixed effects Model

The fixed effects (FE) model is suitable for panel data, such as those for the Eurozone, as it controls for unobserved variables that are constant over time within each country. The aim is to isolate the impact of the independent variables (DS, PI and TXj) on the dependent variable (DP), eliminating the bias that can arise due to specific characteristics of each country, such as culture or structural policies, which do not vary over the period analyzed. The general formula for the fixed effects model is:

$$DP_{it} = \alpha_i \, \beta_1 DS_{it} + \beta_2 PI_{it} + \beta_3 TXj_{it} + \epsilon_{it} \quad (4.8)$$

Where DP_{it} is the dependent variable for country i at time t; DS_{it}, PI_{it} *e* TXj_{it} are the independent variables, α_i is the specific fixed effect for each country i, ϵ_{it} is the idiosyncratic error.

The fixed effects analysis shows that social expenditure (DS) has a positive and significant impact on public debt (DP), with an increase of one pp in social expenditure leading to an increase of around 4.98 pp in public debt. On the other hand, the elderly population (PI) has a negative coefficient of -6.90, suggesting a possible reduction in public debt as the proportion of elderly people increases, but this effect is marginally insignificant at 5% and may be relevant at 10%. The interest rate on 10-year bonds (TXj) has no significant impact on the public debt in the model. Furthermore, 7.57% of the variation in government debt within each country is explained by the variables DS, PI and TXj, while most of the variation is attributed to other factors. The analysis confirms that cross-country differences are relevant and underlines the importance of taking these specific characteristics into account.

Table 8 - The fixed effects (FE) model for the DP, DS, PI and TXj variables

```
Fixed-effects (within) regression               Number of obs      =       160
Group variable: Country                         Number of groups   =        16

R-squared:                                      Obs per group:
     Within  = 0.0757                                         min =        10
     Between = 0.0057                                         avg =      10.0
     Overall = 0.0009                                         max =        10

                                                F(3, 141)          =      3.85
corr(u_i, Xb) = -0.4672                         Prob > F           =    0.0110
```

DP	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
DS	4.975239	1.822196	2.73	0.007	1.372882	8.577596
PI	-6.897635	4.004856	-1.72	0.087	-14.81496	1.01969
TXj	-.3571233	1.856245	-0.19	0.848	-4.026793	3.312547
_cons	88.37409	90.52723	0.98	0.331	-90.59204	267.3402
sigma_u	46.889528					
sigma_e	36.455382					
rho	.62326048	(fraction of variance due to u_i)				

```
F test that all u_i=0: F(15, 141) = 6.43                     Prob > F = 0.0000
```

Source: Stata

- Random effects model

The random effects model (RE) is an econometric approach used for panel data that considers variation both between different units (such as countries) and over time. This model assumes that unobserved differences between groups are random and not correlated with the model's explanatory variables. It is most statistically efficient when it is believed that the variations between groups are random and that there is significant variability that can be captured in the random error term. The general formula for the random effects model is:

$$DP_{it} = \beta_0 + \beta_1 DS_{it} + \beta_2 PI_{it} + \beta_3 TXj_{it} + u_i + \epsilon_{it} \quad (4.9)$$

According to the analysis presented, the DS variable has a coefficient of 2.510876, which indicates that an increase in social spending is associated with an increase of 2.511 pp in public debt (DP). This effect is statistically significant with a p-value of 0.023, less than 0.05. On the other hand, the PI variable has a coefficient of 2.858136, suggesting that an increase in the elderly population is related to an increase of 2.858 in DP. However, the p-value for PI is 0.202, greater than 0.05, indicating that this effect is not statistically significant. The TXj variable has a coefficient of 4.588282, showing that an increase in 10-year bond interest rates is associated with a 4.588 increase in DP. With a p-value of 0.001, less than 0.05, this effect is highly significant. The Wald chi2(3) test with a value of 20.33 and Prob > chi2 = 0.0001 indicates that the model is statistically significant and at least one of the explanatory variables has a significant effect on DP. Stata output, sigma_u = 19.328313 gives the standard deviation of the individual effect, while sigma_e = 36.455382 gives the standard deviation of the idiosyncratic error. The value of rho = 0.21942229 suggests that 21.94 per cent of the total variation in DP is attributable to differences between countries, while the rest is explained by variability within countries.

Table 9 - The random effects model (RE) for the DP, DS, PI and TXj variables

```
Random-effects GLS regression                   Number of obs     =       160
Group variable: Country                         Number of groups  =        16

R-squared:                                      Obs per group:
     Within  = 0.0204                                         min =        10
     Between = 0.4697                                         avg =      10.0
     Overall = 0.2547                                         max =        10

                                                Wald chi2(3)      =     20.33
corr(u_i, X) = 0 (assumed)                      Prob > chi2       =    0.0001
```

DP	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
DS	2.510876	1.100911	2.28	0.023	.3531299	4.668623
PI	2.858136	2.237941	1.28	0.202	-1.528148	7.24442
TXj	4.588282	1.441565	3.18	0.001	1.762866	7.413697
_cons	-37.3468	39.44474	-0.95	0.344	-114.6571	39.96348
sigma_u	19.328313					
sigma_e	36.455382					
rho	.21942229	(fraction of variance due to u_i)				

Source: Stata

4.4.3.Hausman test

The Hausman test was carried out to compare the coefficients estimated by the fixed effects model and the random effects model, in order to decide which model was more appropriate for the data studied, as mentioned above. This test is calculated using the following formula:

$$H = (\hat{\beta}_{FE} - \hat{\beta}_{RE})' [Var(\hat{\beta}_{RE}) - Var(\hat{\beta}_{FE})]^{-1} (\hat{\beta}_{FE} - \hat{\beta}_{RE}) \quad (4.10)$$

Where $\hat{\beta}_{FE}$ is the coefficient of the fixed effects model and $\hat{\beta}_{RE}$ is the coefficient of the random effects model. If the value of H is significant, we reject the random effects model and choose the fixed effects model.

Table 10 - The Hausman test

	Coefficients (b) fe_model	(B) re_model	(b-B) Difference	sqrt(diag(V_b-V_B)) Std. err.
PI	-6.897635	2.858136	-9.755771	3.321218
DS	4.975239	2.510876	2.464363	1.452031
TXj	-.3571233	4.588282	-4.945405	1.169417

b = Consistent under H0 and Ha; obtained from **xtreg**.
B = Inconsistent under Ha, efficient under H0; obtained from **xtreg**.

Test of H0: Difference in coefficients not systematic

chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 4.19
Prob > chi2 = 0.2414
(V_b-V_B is not positive definite)

Source: Stata

The Hausman test, shown in figure 14, is used to compare the suitability of the fixed effects and random effects models. The null hypothesis (H0) suggests that the fixed effects model is appropriate, indicating that the estimators are consistent and efficient. The alternative hypothesis (Ha) suggests that the fixed effects model is more appropriate, indicating a correlation between the random effects and the explanatory variables, which would make the random effects model inconsistent.

Analysis of the coefficients shows significant differences between the two models for the variables analyzed:

- PI - In the fixed effects model, the coefficient is -6.897635, while in the random effects model it is 2.858136, resulting in a difference of -9.755771.
- DS - In the fixed effects model, the coefficient is 4.975239, compared to 2.510876 in the random effects model, resulting in a difference of 2.464363.
- TXj - The coefficient in the fixed effects model is -0.3571233, while in the random effects model it is 4.588282, showing a difference of -4.945405.

The Hausman test calculates a Chi2(3) value = 4.19, with an associated probability of 0.2414. As this probability is greater than 0.05, the null hypothesis cannot be rejected, indicating that the differences between the coefficients of the fixed and random effects models are not systematic.

Therefore, the fixed effects model is considered the most appropriate for the data studied in this dissertation. According to this model, social spending and interest rates on 10-year bonds have a statistically significant impact on public debt (DP). However, the impact of the elderly population (PI) is not significant, suggesting that other factors not captured by the model may be influencing this relationship.

Some factors that can influence the relationship between the elderly population (PI) and public debt (DP) include: Social Security Policies: The generosity of social security systems can increase the impact of the elderly population on public debt; Health Systems: The efficiency of health systems can affect age-related costs; Labor Market and Active Ageing: The participation of the elderly in the labor market can reduce fiscal pressure; Economic Growth: Growing economies can mitigate the impact of ageing on public debt; Savings and Investment Rates: Savings and investments by the elderly can alleviate pressure on public debt; Fiscal Policy and Historical Indebtedness: Countries with high levels of indebtedness may be more affected by population ageing; Intergovernmental Transfers: In decentralized systems, the central government may absorb more costs related to ageing; Demographics and Migration: Immigration and birth rates may influence the impact of the elderly population on public debt; These factors may explain the lack of statistical significance of the coefficient of the PI variable, indicating the need for a more detailed analysis of local specificities. Also, as it has DS, the effect of ageing could be that way: it affects DS, which in turn affects DP.

4.4.4. Arellano-Bond/GMM Dynamic Model

The Arellano-Bond/GMM Dynamic model is a dynamic panel estimation that uses the Arellano-Bond method, which is suitable for situations in which the objective is to capture the dynamics of dependent variables over time and in panel data, making it possible to deal with endogeneity problems. In the context of this dissertation, the Arellano-Bond/GMM dynamic model is used to capture the dynamic effects of DP in Eurozone countries, analyzing how the dependent variable DP is influenced by PI, DS and TXj, taking into account possible time dependence effects.

The basic formula for a dynamic equation of this model is:

$$DP_{it} = \alpha + pDP_{i(t-1)} + \beta_1 DS_{it} + \beta_2 PI_{it} + \beta_3 TXj_{it} + \epsilon_{it} \quad (4.11)$$

Where $DP_{i(t-1)}$ is the public debt lag, p is the lag coefficient, $DS_{it}, PI_{it}\ e\ TXj_{it}$ are the explanatory variables and ϵ_{it} is the error term. Also, robust standard deviations by country were used.

Table 11 - The Arellano-Bond/GMM Dynamic model

```
Arellano-Bond dynamic panel-data estimation     Number of obs     =       128
Group variable: Country                         Number of groups  =        16
Time variable: Year
                                                Obs per group:
                                                              min =         8
                                                              avg =         8
                                                              max =         8

Number of instruments =     41                  Wald chi2(4)      =     63.04
                                                Prob > chi2       =    0.0000
One-step results
                                (Std. err. adjusted for clustering on Country)
```

DP	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
DP						
L1.	-.0069748	.0108329	-0.64	0.520	-.0282069	.0142573
PI	-3.57842	1.704587	-2.10	0.036	-6.91935	-.2374903
DS	3.59191	.499818	7.19	0.000	2.612285	4.571535
TXj	-1.781412	.5341796	-3.33	0.001	-2.828385	-.7344391
_cons	63.06664	31.547	2.00	0.046	1.235645	124.8976

```
Instruments for differenced equation
        GMM-type: L(2/.).DP
        Standard: LD.DP D.PI D.DS D.TXj
Instruments for level equation
        Standard: _cons
```

Source: Stata

In the model analyzed, for Lagged Public Debt (DP L1.): The coefficient is -0.0069, indicating a small and non-significant negative effect of past public debt on current debt (p = 0.520); on Elderly Population (PI): The coefficient is -3.578, suggesting that an increase in the elderly population is associated with a significant reduction in public debt (p = 0.036); on Social Expenditure (DS): The coefficient is 3.591, showing that an increase in social spending is positively correlated with a significant increase in public debt (p = 0.000); on the 10-Year Bond Interest Rate (TXj): The coefficient is -1.784, indicating that an increase in the interest rate is related to a significant decrease in public debt (p = 0.001). Regarding the Intercept (_cons): The value is 63.06664, meaning that in the absence of the other variables, the base level of public debt would be high and significant (p = 0.046).

To summarize, past public debt has no significant impact on current debt. However, taking into account that this result was not expected, the elderly population reduces public debt, social spending increases it and higher interest rates also contribute to a reduction in public debt.

4.5. The Im-Pesaran-Shin (IPS) stationarity test

The stationarity test is fundamental in this dissertation because the variables analyzed are panel data from 2012 to 2021 for various Eurozone countries. Time series analysis requires checking for stationarity to ensure that the statistical properties of the variables, such as the mean and variance, do not change over time.

If the variables are not stationary, there may be a spurious relationship between them, which jeopardizes the validity of the regression results and the econometric models applied. By carrying out the stationarity test, it is possible to determine whether it is necessary to apply transformations (such as differentiation) to the variables.

The choice of the IPS test for panel data in this thesis is justified by the heterogeneity between Eurozone countries, which may have different time paths for variables such as public debt, social spending and interest rates.

4.5.1. Variable DS

Table 12 - The Im-Pesaran-Shin (IPS) stationarity test of DS variable

Im-Pesaran-Shin unit-root test for DS

H0: All panels contain unit roots — Number of panels = 16
Ha: Some panels are stationary — Number of periods = 10

AR parameter: Panel-specific — Asymptotics: T,N -> Infinity sequentially
Panel means: Included
Time trend: Not included

ADF regressions: No lags included

	Statistic	p-value	Fixed-N exact critical values 1%	5%	10%
t-bar	-1.7436		-2.060	-1.890	-1.800
t-tilde-bar	-1.5011				
Z-t-tilde-bar	-1.2585	0.1041			

Source: Stata

Figure 15 shows the result of the Im-Pesaran-Shin (IPS) test to verify the stationarity of the SD (Social Expenditure) variable in the panel data. The purpose of this test is to check for the presence of unit roots, i.e. to test whether the time series is non-stationary.

Given that:

- H0 (Null Hypothesis): All panel series have a unit root (are non-stationary).
- Ha (Alternative hypothesis): Some panel series are stationary.

It can be seen from this test that the p-value of 0.1041 is higher than the common significance levels (1%, 5%, 10%), which implies that we cannot reject the null hypothesis that all series have a unit root. Therefore, there is not enough evidence to conclude that the DS variable is stationary.

Based on these IPS test results, the SD (Social Expenditure) variable is not stationary at the 10 per cent significance level. This suggests that it is necessary to apply transformations (such as differentiation) to make the series stationary.

4.5.2.Variable PI

The figure below shows the result of the Im-Pesaran-Shin (IPS) test to verify the stationarity of the PI variable (Elderly Population, as a percentage of the total population) in panel data.

Table 13 - The Im-Pesaran-Shin (IPS) stationarity test of PI variable

```
. xtunitroot ips PI

Im-Pesaran-Shin unit-root test for PI
-----------------------------------------------------------------------------
H0: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =     10

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included

ADF regressions: No lags included
-----------------------------------------------------------------------------
                                                 Fixed-N exact critical values
                     Statistic      p-value        1%      5%      10%
-----------------------------------------------------------------------------
 t-bar                -1.1965                    -2.060  -1.890  -1.800
 t-tilde-bar          -0.6296
 Z-t-tilde-bar         3.5711        0.9998
-----------------------------------------------------------------------------
```

Source: Stata

According to the test, the p-value of 0.9998 is significantly higher than the common significance levels (1%, 5%, 10%). This means that we cannot reject the null hypothesis that all the series have a unit root. In other words, there is not enough evidence to state that the PI variable is stationary.

The results indicate that the PI (Elderly Population) variable is non-stationary at the 10% significance level. It would therefore be necessary to carry out transformations, such as differentiation, to make this variable stationary and ensure that econometric analyses are not influenced by spurious relationships.

4.5.3. Variable TXj

Table 14 - The Im-Pesaran-Shin (IPS) stationarity test of TXj variable

```
Im-Pesaran-Shin unit-root test for TXj
-----------------------------------------------------------------------------
H0: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =     10

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included

ADF regressions: No lags included
-----------------------------------------------------------------------------
                                                 Fixed-N exact critical values
                     Statistic      p-value        1%      5%      10%
-----------------------------------------------------------------------------
 t-bar                -2.5588                    -2.060  -1.890  -1.800
 t-tilde-bar          -1.7984
 Z-t-tilde-bar        -2.9060        0.0018
-----------------------------------------------------------------------------
```

Source: Stata

By testing the TXj variable, we can analyse that: the p-value of 0.0018 is lower than all the common significance levels (1%, 5%, 10%). This means that we can reject the null hypothesis that all the series have a unit root. In other words, there is significant evidence that some series of the TXj variable are stationary.

The results indicate that the TXj variable (10-year bond interest rates) shows evidence of stationarity at the 1% significance level. Therefore, this variable can be used directly in econometric models without the need for additional transformations, such as differentiation.

4.5.4. Variable DP

The p-value (0.1543) of the DP variable, as can be seen in figure 18, is greater than the significance levels of 1%, 5% and 10%, suggesting that we cannot reject the null hypothesis (H0) that all the time series contain a unit root. This indicates that the DP variable is not stationary in the panels analyzed.

In practical terms, the Public Debt (DP) variable shows a non-stationary trend over time for the 16 countries, which may indicate the need for transformation (e.g. differentiation) before being included in econometric models to avoid spurious results.

Table 15 - The Im-Pesaran-Shin (IPS) stationarity test of DP variable

Im-Pesaran-Shin unit-root test for DP

H0: All panels contain unit roots — Number of panels = 16
Ha: Some panels are stationary — Number of periods = 10

AR parameter: Panel-specific — Asymptotics: T,N -> Infinity sequentially
Panel means: Included
Time trend: Not included

ADF regressions: No lags included

	Statistic	p-value	Fixed-N exact critical values 1%	5%	10%
t-bar	-6.2112		-2.060	-1.890	-1.800
t-tilde-bar	-1.4577				
Z-t-tilde-bar	-1.0182	0.1543			

Source: Stata

4.6. Differencing non-stationary variables: DS, PI and DP

4.6.1. Differencing non-stationary variables: DS, PI and DP

Differentiation is a way of making non-stationary time series, such as DS, PI and DP, stationary. This is crucial to avoid spurious results and ensure that the estimates of econometric models are reliable and consistent. To deal with the non-stationarity of variables in econometric models, we need to apply differencing. Differentiation transforms non-stationary variables into stationary ones by removing long-term trends. The aim is to create a new variable that is the difference between consecutive values in the

original series. As the variables analyzed are non-stationary, as noted in Annex A, Table 16, differentiation must be applied to them.

The results of the Im-Pesaran-Shin (IPS) unit root tests shown in the tables below for the differentiated variables D_PI, D_DS and D_DP show that, in all cases, the p-values are extremely low (less than 0.01), allowing us to reject the null hypothesis that all the series have a unit root. Therefore, its concluded that the differentiated variables are stationary, which indicates that they are suitable for subsequent econometric modelling.

Table 17, 18 and 19 - The Im-Pesaran-Shin (IPS) stationarity test of D_DS, D_DP and D_PI variable

```
Im-Pesaran-Shin unit-root test for D_PI
------------------------------------------------------------------------------
H0: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =      9

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included

ADF regressions: No lags included
------------------------------------------------------------------------------
                                                Fixed-N exact critical values
                     Statistic      p-value        1%      5%      10%
------------------------------------------------------------------------------
t-bar                  -2.8181                    -2.060  -1.890  -1.800
t-tilde-bar            -1.8122
Z-t-tilde-bar          -3.1310       0.0009
------------------------------------------------------------------------------
```

```
Im-Pesaran-Shin unit-root test for D_DS
------------------------------------------------------------------------------
H0: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =      9

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included

ADF regressions: No lags included
------------------------------------------------------------------------------
                                                Fixed-N exact critical values
                     Statistic      p-value        1%      5%      10%
------------------------------------------------------------------------------
t-bar                  -3.2595                    -2.060  -1.890  -1.800
t-tilde-bar            -2.0997
Z-t-tilde-bar          -4.7147       0.0000
------------------------------------------------------------------------------
```

```
. xtunitroot ips D_DP

Im-Pesaran-Shin unit-root test for D_DP
------------------------------------------------------------------------------
H0: All panels contain unit roots           Number of panels  =     16
Ha: Some panels are stationary              Number of periods =      9

AR parameter: Panel-specific                Asymptotics: T,N -> Infinity
Panel means:  Included                                   sequentially
Time trend:   Not included

ADF regressions: No lags included
------------------------------------------------------------------------------
                                                Fixed-N exact critical values
                     Statistic      p-value        1%      5%      10%
------------------------------------------------------------------------------
t-bar                  -6.8741                    -2.060  -1.890  -1.800
t-tilde-bar            -2.0689
Z-t-tilde-bar          -4.5452       0.0000
------------------------------------------------------------------------------
```

Source: Stata

4.6.2. OLS Model of D_DP, D_DS, D_PI and TXj variables

In the analysis conducted above, the first differences of social spending (D_DS), the elderly population (D_PI), and public debt (D_DP) were utilized to examine their relationships through correlation and multicollinearity tests. The findings indicated no evidence of strong correlations among these variables, which is crucial for ensuring the validity of subsequent econometric models. The regression output shows that the overall model is marginally significant (Prob > F = 0.0626), with an R-squared value of 0.0507, suggesting that only about 5% of the variability in D_DP can be explained by the model. The coefficient for D_DS is positive (3.03), but with a p-value of 0.157, it is not statistically significant, indicating that changes in social spending do not have a strong effect on public debt in this model.

Similarly, the coefficient for D_PI is positive (11.17) but also lacks statistical significance (p = 0.619), suggesting that changes in the elderly population are not significantly impacting public debt levels. In contrast, the variable for the 10-year bond interest rates (TXj) has a statistically significant negative coefficient (-3.93, p = 0.034), indicating that higher interest rates are associated with lower levels of public debt.

The correlation matrix further supports the findings of weak relationships, with correlations between D_DS and D_PI at -0.0169, D_DS and TXj at -0.1235, and D_PI and TXj at 0.1487. These values suggest that there are no strong linear associations among these variables, which is essential for ensuring that multicollinearity does not affect the results of the regression analysis.

Table 20 and 21 – OLS Model and correlation test of D_DP, D_DS, D_PI and TXj variables

```
. regress D_DP D_DS D_PI TXj
```

Source	SS	df	MS		
Model	11266.0684	3	3755.35612	Number of obs	= 144
Residual	210889.771	140	1506.35551	F(3, 140)	= 2.49
				Prob > F	= 0.0626
Total	222155.84	143	1553.53734	R-squared	= 0.0507
				Adj R-squared	= 0.0304
				Root MSE	= 38.812

D_DP	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
D_DS	3.029575	2.12923	1.42	0.157	-1.180026	7.239177
D_PI	11.17025	22.43787	0.50	0.619	-33.19064	55.53113
TXj	-3.932489	1.838754	-2.14	0.034	-7.567804	-.2971744
_cons	-1.117902	7.584828	-0.15	0.883	-16.11352	13.87771

```
. correlate D_DS D_PI TXj
(obs=144)
```

	D_DS	D_PI	TXj
D_DS	1.0000		
D_PI	-0.0169	1.0000	
TXj	-0.1235	0.1487	1.0000

Source: Stata

Following the initial correlation and multicollinearity assessments, the fixed effects (FE) and random effects (RE) models , as shown in Annex, tables 22 and 23, were employed to analyze the relationship between the first differences of public debt (D_DP), social spending (D_DS), the elderly population (D_PI), and the 10-year bond interest rates (TXj). The fixed effects model accounts for unobserved heterogeneity by analyzing within-group variations, which is particularly beneficial when examining the effects of variables over time within countries. In the FE model, D_DS has a coefficient of 2.00, indicating a positive but statistically insignificant relationship with D_DP (p = 0.342). In contrast, D_PI shows a significant positive impact (coefficient = 111.20, p = 0.008), suggesting that increases in the elderly population are associated with higher public debt levels. The TXj variable has a significant negative coefficient (-9.02, p = 0.000), indicating that higher interest rates correlate with lower public debt. One possible explanation for this result may be that when interest rates start to increase, governments act to reduce public debt to curtail that increase. Conversely, the RE model yields a coefficient for D_DS of 2.92, again indicating a positive but borderline significant relationship (p = 0.167). D_PI's coefficient in this model is not significant (18.67, p = 0.441), while TXj presents a negative coefficient (-4.56, p = 0.018), suggesting a weaker relationship compared to the FE model.

4.6.3.Hausman test

Table 24 - The Hausman test

```
. hausman fe_model re_model

                 ---- Coefficients ----
                 (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
                 fe_model     re_model       Difference       Std. err.
-------------------------------------------------------------------------
        D_DS     2.004767     2.916702       -.9119351              .
        D_PI     111.2027     18.66891        92.53378        33.67443
         TXj    -9.016478    -4.557522       -4.458956        1.512771
-------------------------------------------------------------------------
                           b = Consistent under H0 and Ha; obtained from xtreg.
            B = Inconsistent under Ha, efficient under H0; obtained from xtreg.

Test of H0: Difference in coefficients not systematic

    chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =  12.69
Prob > chi2 = 0.0054
(V_b-V_B is not positive definite)
```

Source: Stata

The analysis of the relationship between public debt (DP), social spending (D_DS), and the elderly population (D_PI) reveals significant insights from the econometric models applied. The Hausman test indicates that the fixed effects model is the most appropriate, as it suggests systematic differences in coefficients between the fixed and random effects models. In terms of results, D_PI shows a positive effect on DP, albeit quite large, while D_DS is not statistically significant in the first differences model, where D_PI is significant.

Interestingly, the effect of the interest rate (TXj) differs across models, being positive in the levels model and negative in the differences model. This negative effect in the differences model is particularly valuable since it accounts for stationary variables, providing potentially more reliable insights. The Arellano-Bond model was found to be less suitable due to its indication that DP does not depend significantly on past values. Overall, these findings underscore the complexity of the relationships among the variables and highlight the need for careful model selection in econometric analyses.

In this dissertation, the decision was made to perform stationarity tests and variable differentiation after the initial construction of the econometric models. This choice was based on the aim of initially exploring the data, i.e., starting by modeling the data without rigorous verification of their properties, in order to understand the relationships between the variables before delving deeper into their structure.

Econometric models were first employed to identify patterns or relationships among the variables, helping to comprehend the data dynamics and influencing the choice of transformations, such as differentiation. After the initial model construction, verifying stationarity allows for a more critical interpretation of the results, identifying whether the findings are valid or influenced by issues such as non-stationarity, which can lead to misleading conclusions. In this case, the variables were found to be non-stationary (except for TXj), so differentiation was applied as a corrective step, adjusting the models

to ensure that the econometric assumptions are met, and the results are robust. This process serves as a form of validation, ensuring that the estimated models are appropriate and that the inferences drawn from them are reliable.

4.7. Other factors affecting debt: a non-econometric approach

4.7.1. The implications that the GDP growth has in the variables analyzed

GDP growth is a very relevant factor in determining the ability of the EZ countries to manage their debts and social spending in a sustainable way in the face of a demographic change: population ageing.

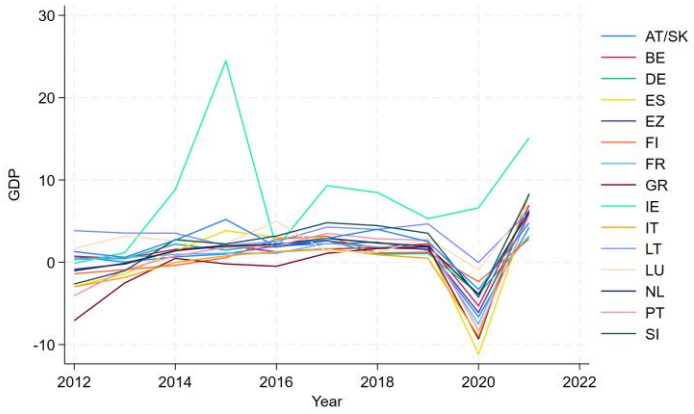


Figure 5 - GDP growth between 2012 and 2021 in Eurozone countries

Source: Stata; OECD

GDP growth has several implications for the variables analyzed:

- Social Expenditure (DS): Economic growth allows for higher tax revenues, which can increase social spending. Between 2012 and 2021, countries like Germany and France, with robust welfare systems, increased these expenses during the economic recovery.
- Public debt (DP): GDP growth reduces the debt/GDP ratio, even with stable or growing nominal debt, as the denominator (GDP) increases. Countries like Greece, Italy and Portugal have maintained high public debt due to weak growth and austerity.
- Elderly Population (PI): A strong GDP mitigates the effects of ageing, with higher revenues and investments in policies for the elderly. Without sufficient growth, pressure on pensions and healthcare increases, as occurred in several Eurozone countries between 2012 and 2021.
- Interest rates on 10-year bonds (TXj): Economic growth reduces interest rates on public debt. Germany, with stable growth, had lower interest rates, while Greece and Italy, with unstable growth, faced higher interest rates due to perceived risk.

4.7.2.Level of Inflation

Inflation also plays an important role in determining public debt interest rates, in addition to the 4 variables analyzed in this dissertation. In periods of high inflation, creditors demand higher interest rates to compensate for the loss of purchasing power over time.

In addition, inflation can impact the real value of the debt, since long-term debts in national currency can become easier to pay in nominal terms. However, a high inflation environment can generate uncertainty about future monetary policy, which can increase debt financing costs.

Figure 27 shows the evolution of the inflation rate (INF) in Eurozone countries between 2012 and 2021. As can be seen at the start of 2012, many countries had low or even negative inflation rates, reflecting a fragile economic environment, possibly still under the effects of the 2008 global financial crisis and the European sovereign debt crisis. Between 2013 and 2015, inflation rates remained relatively low, with some countries facing deflation (negative inflation rates).

This scenario is fought by the monetary policy of the European Central Bank (ECB), which adopted stimulus measures to deal with low inflation and stimulate recovery. In 2017 and 2018, inflation rates recovered, with most countries reaching rates above 2%, which is the ECB's inflation target. This may be related to the eurozone's moderate economic growth.

The sharp drop in 2020 reflects the impact of the COVID-19 pandemic, which has caused a global slowdown in economic activity and temporary deflation in some countries. The recovery in 2021, with some countries exceeding 4 per cent, which reflects inflationary pressures arising from the economic reopening with rising energy prices, supply chain disruptions and other factors.

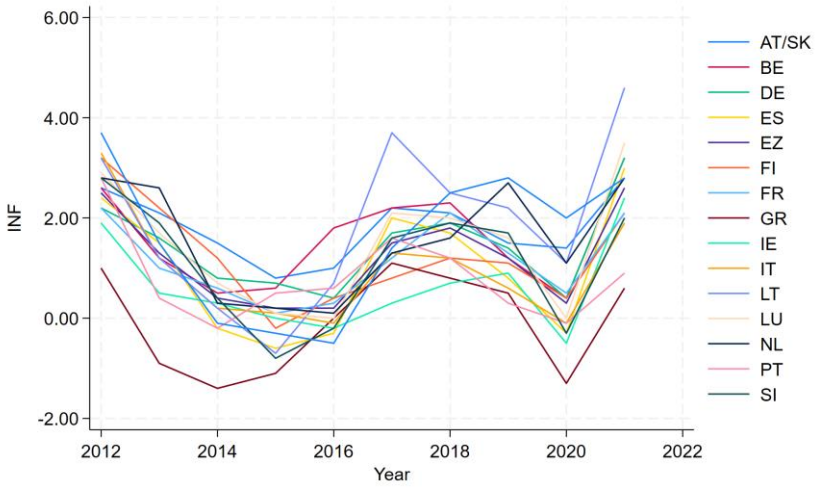


Figure 6 - Evolution of the level of inflation from 2012 to 2021 in the Eurozone countries

Source: Stata; OECD

Although there are similar general trends, the graph shows variations between countries. Some countries experienced sharper fluctuations, such as Austria and Slovakia and Greece, while others, such as Germany, had more contained variations. Some countries reflected consistently higher inflation rates throughout the period, while others maintained more stable levels.

In this dissertation, inflation is one of the relevant factors for understanding public debt (DP) rates in a reality of demographic change. The graph suggests that inflation can have a significant impact on the evolution of public debt. When inflation is high, the real value of public debt can decrease, as the purchasing power of the currency falls, reducing the real cost of the debt. However, high inflation rates can also increase interest rates (TXj), which in turn raises the cost of servicing the debt. Periods of lower inflation or deflation, such as in 2014 and 2015, may have increased the real cost of DP, requiring additional fiscal efforts on the part of governments to contain the increase in indebtedness. The ECB, by controlling inflation through its monetary policies, plays a key role in managing DP. However, demographic challenges, such as population ageing (PI), can complicate this process, since an older population can put pressure on higher social spending (DS), which is a determinant of DP. The fall in inflation rates in 2020 reflects the sharp economic slowdown caused by the pandemic. The rapid recovery in inflation rates in 2021 may have contributed to increasing uncertainty about the sustainability of DP in some countries, as governments adopted fiscal stimulus measures that further increased debt levels. One major initiative was the continuation of expansive fiscal policies that allowed governments to maintain high levels of spending without the usual constraints from the European Union regarding budget deficits. This included direct support for businesses and individuals, job protection programs, and other economic assistance aimed at fostering recovery. For example, the European Union's *Next Generation EU* recovery plan, which amounted to €750 billion, was designed to provide financial aid to member states to stimulate their economies. This plan specifically aimed to support public investment and promote reforms that could enhance long-term growth and sustainability. Additionally, countries such as Germany and France expanded social welfare programs and provided significant financial support to key sectors hit hard by the pandemic, including tourism and hospitality.

In order to understand the relationship between the level of Inflation (INF) and Public Debt, Pearson's correlation is used again. In this case, the Pearson correlation (r) is calculated as follows:

$$r_{DP,INF} = \frac{\sum(DP_i - \overline{DP})(INF_i - \overline{INF})}{\sqrt{\sum(DP_i - \overline{DP})^2 \sum(INF_i - \overline{INF})^2}} \qquad (4.12)$$

Where $r_{DP,INF}$ is the Pearson correlation coefficient between INF (inflation rate) and DP (Public Debt), DP_i represents the public debt and INF_i represents the inflation rate.

Table 25 - Pearson's correlation between INF and DP

(obs=160)

	DP	INF
DP	1.0000	
INF	-0.1723	1.0000

Source: Stata

Figure 23 shows the Pearson correlation between public debt (DP) and inflation (INF), with 160 observations. The correlation coefficient between DP and INF is -0.1723, which indicates a weak negative correlation between these variables. In other words, when INF increases, DP tends to decrease slightly, and vice versa. However, the value of the correlation is quite low, suggesting that this relationship is not very strong. This could mean that factors other than inflation have a greater impact on DP.

The negative correlation suggests that an increase in inflation can reduce the real value of public debt, since inflation 'devalues' the currency, reducing the real value of financial obligations. This relationship is negative, but far from -1, which would indicate a perfect inverse relationship. Thus, inflation alone does not strongly explain the variation in public debt.

This result suggests that although inflation has some impact on public debt, the relationship is not very strong in the context analyzed. The behavior of public debt may be influenced by other factors, such as GDP growth, interest rates (TXj), or social spending (DS), which may play a more significant role in explaining the variation in public debt, as seen above. This indicates that, although inflation is relevant to the analysis, it should be considered together with other variables in the model.

In the analysis of the correlation between differentiated public debt (D_DP) and differentiated inflation (D_INF), as shown in Annex A, Table 26, the correlation coefficient is -0.0072, with a significance level of 0.9321. This indicates an extremely weak negative relationship between public debt and inflation, suggesting that changes in inflation do not significantly correlate with changes in public debt levels.

The differentiation of the inflation variable was performed to ensure that both D_DP and D_INF were stationary, a crucial step in time series analysis. Non-stationary data can produce spurious results, making it essential to work with first differences to accurately capture the dynamics of these economic variables.

The near-zero correlation observed here implies that the interaction between public debt and inflation is minimal, indicating that inflation does not play a significant role in influencing public debt

changes in the sample analyzed. This outcome underscores the complexity of the relationship between these macroeconomic factors, suggesting that additional variables may need to be considered for a more comprehensive understanding of their dynamics.

4.7.3.Savings rate (in % of GDP)

In a context of demographic change, a country's savings rate (savings rate of the economy) can change significantly. Older populations tend to save more while they are in the labor market to support their pensions, which increases the savings rate. However, as people retire, this level of saving declines, which has implications for public debt financing as there are fewer resources to invest in government bonds. With lower domestic savings, governments may have to seek more external financing, which can increase interest rates on PD.

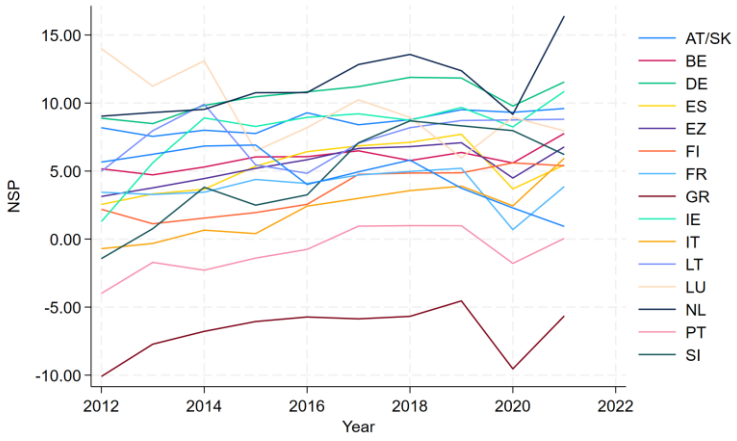


Figure 7 - Evolution of the Savings Rate in the Eurozone countries from 2012 to 2021

Source: Stata; OECD

As Figure 7 shows, countries such as Germany, Ireland and the Netherlands show an upward trend in the savings rate over the period analyzed. Germany, for example, increased from 8.89 per cent in 2012 to 11.55 per cent in 2021. Ireland and the Netherlands also show a significant development, especially the Netherlands, which reaches 16.40 per cent in 2021. This could indicate greater fiscal discipline and an increase in household savings, potentially leading to greater financial resilience, which could reduce reliance on public debt as a source of financing.

On the other hand, some countries show significant volatility, such as Spain and France. Spain experienced a sharp decline from 7.71% to 3.69% (2019 to 2020), followed by a moderate recovery to 5.45% in 2021. France experienced a sharp drop in savings in 2020, with the rate falling to 0.69 per cent, with a partial recovery to 3.86 per cent in 2021. This suggests that for these countries, economic factors such as external shocks or financial crises can have a significant impact on domestic savings capacity.

Countries such as Greece and Portugal have consistently had a negative or very low saving rate until recent years. Greece, for example, had a negative NSP, but showed an improving trend from -10.10 per cent in 2012 to -5.65 per cent in 2021. Portugal had a negative NSP for most of the period but showed a recovery to reach a slightly positive value of 0.05 per cent in 2021. These negative rates indicate that the population is consuming more than it is saving, which can increase financial vulnerability and, consequently, a greater reliance on external financing or DP.

In the context of this thesis, the evolution of the NPS is fundamental to analyze the impact on the public debt (DP) of the euro area countries. The budget deficit tends to reduce domestic savings. On the other hand, when the savings rate is low or negative, as in Portugal or Greece, these countries find it more difficult to finance their deficits without resorting to debt, which worsens the DP. Countries with higher savings rates, such as Germany, Ireland and the Netherlands, tend to have a more stable fiscal situation, with less pressure on public debt. This may be related to the negative correlation observed between savings and public debt, as measured by the Pearson correlation. Countries with lower savings rates, such as Greece and Portugal, face greater fiscal difficulties and are forced to rely on external financing or increase public debt to meet their spending needs.

Demographic change, particularly the ageing of the population, can have a direct impact on the NSP. In countries with an ageing population, savings tend to fall as pensioners begin to consume their savings. This can aggravate the problem of public debt, as less domestic savings are available to finance deficits.

To understand the relationship between the savings rate (NSP) and government debt, Pearson's correlation is again used. In this case, the Pearson's correlation (r) is calculated as follows:

$$r_{DP,NSP} = \frac{\sum(DP_i - \overline{DP})(NSP_i - \overline{NSP})}{\sqrt{\sum(DP_i - \overline{DP})^2 \sum(NSP_i - \overline{NSP})^2}} \qquad (4.13)$$

Where $r_{DP,NSP}$ is the Pearson correlation coefficient between NSP (saving rate) and DP (public debt), DP_i stands for public debt and NSP_i for the saving rate.

According to Figure 26 below, the correlation between DP and NSP = -0.6409, a negative value indicating an inverse correlation between the savings rate and public debt. In other words, as the saving rate increases, public debt tends to decrease. The correlation coefficient of -0.6409 is moderately strong and indicates a significant relationship between these variables.

Table 27 - Pearson's correlation between NSP and DP

(obs=160)

	DP	NSP
DP	1.0000	
NSP	-0.6409	1.0000

Source: Stata

This negative correlation can be explained by the fact that the deficit reduces national savings. On the other hand, countries with low domestic savings may need to borrow more to finance their expenditure, which leads to an increase in public debt. This result is consistent with the idea that the sustainability of DP is related to a country's ability to generate enough domestic savings to finance its spending. Inflation, economic growth and savings could be variables to consider in the DP model in future work.

In the analysis presented in Annex A, Table 28, the first differentiation of the savings rate (D_NSP) was conducted, and its correlation with differentiated public debt (D_DP) was examined. The correlation coefficient obtained is -0.1532, with a significance level of 0.0668. This indicates a weak negative relationship between public debt and the savings rate, suggesting that an increase in public debt may correspond with a decrease in savings, although this relationship lacks strong statistical support.

The differentiation of NSP was necessary to achieve stationarity, which is vital for ensuring that the statistical analysis is valid. Non-stationary data can lead to misleading inferences, thus transforming the variables into first differences allows for a clearer understanding of the dynamics at play between public debt and savings rates. Overall, the weak correlation implies that while there is a slight inverse relationship, the interaction between public debt and savings is likely influenced by various other factors. This complexity highlights the need for further exploration of the underlying dynamics governing these macroeconomic variables.

4.8. ECB Monetary Policies and DP Rates in the Eurozone: The Role of Demographics and Life Expectancy

The ECB's monetary policies, especially by keeping interest rates low or negative over the last decade, have had a significant impact on public debt rates in the Eurozone. In a context of ageing populations, where there is greater demand for public debt due to increased social spending, these lower interest rate have allowed governments to refinance their debts at a lower cost. Countries like Italy and Greece, which

have high public debts, have benefited from these favorable credit conditions, keeping their debts manageable.

In addition to interest rates, the ECB implemented asset purchase programmes, such as the PEPP (Pandemic Emergency Purchase Programme), which helped reduce governments' borrowing costs by increasing demand for government bonds and lowering yields. During the COVID-19 pandemic, many countries increased their debts to finance emergency measures, and the ECB's support was crucial in keeping debt costs under control, despite the fact that Eurozone debt rose to 97.3 per cent of GDP in 2020.

With the ageing of the population, social spending, mainly related to pensions and health, has increased, putting pressure on public finances. The ECB's expansionary policies have helped to alleviate these pressures, allowing these expenses to be financed at a lower cost. However, the eventual normalization of interest rates could significantly increase debt servicing costs, creating challenges, especially for countries with high levels of public debt and ageing populations.

4.9. Measures and policies adopted by Eurozone countries

A number of measures and policies have been adopted by Eurozone countries to combat the profound impact that demographic change has on public finances, particularly concerning social spending, public debt, and bond interest rates.

One significant response has been pension reform. Countries like Germany, France, and Italy have restructured their pension systems to address the challenges posed by an aging population. These reforms typically include raising the retirement age and modifying pension calculation formulas to ensure the financial sustainability of the systems. For instance, in 2010, France gradually raised the retirement age from 60 to 62, while Germany increased it from 65 to 67 by 2029 (OECD, 2019; European Commission, 2021).

Another key measure has been the promotion of labor market participation, particularly aimed at older individuals and women. This initiative has involved retraining programs and tax incentives designed to extend working life. Denmark’s "active ageing" policies exemplify this approach, encouraging older workers to remain in the labor force longer (Börsch-Supan et al., 2020).

Fiscal adjustments and debt reduction have also been widely adopted, especially by countries like Portugal and Greece, which implemented strict fiscal adjustment programs following the 2008 financial crisis. These adjustments included significant cuts in public spending and tax increases. One notable example is Portugal's Troika adjustment program, which involved austerity measures that successfully reduced the fiscal deficit and stabilized public debt levels (IMF, 2014).

Moreover, some Eurozone countries have begun to view immigration as a potential solution to the challenge of population aging. Immigration can help expand the active labor force and contribute to economic growth. Germany, in particular, has been proactive in promoting the immigration of skilled workers from other EU countries to fill gaps in its labor market (Kahanec & Kurekova, 2017).

Investment in innovation and technology is another critical strategy adopted across Eurozone countries, particularly in the healthcare sector, to mitigate the costs associated with an aging population and enhance productivity.

Finally, Eurozone countries have recognized the importance of education and skills development to equip their workforce for evolving market demands. Initiatives like Germany's Industry 4.0 align with this objective, integrating advanced technologies such as artificial intelligence and automation into manufacturing processes to boost competitiveness on a global scale (Schwab, 2017).

Family-friendly policies have also been essential in promoting higher birth rates. Countries like Germany and France have implemented comprehensive family policies that include generous parental leave benefits, enabling parents to take substantial time off while receiving a portion of their salary. This approach aims to foster a better work-life balance, making it more feasible for families to consider having more children (OECD, 2020; European Commission, 2021)

.

CHAPTER 5

Conclusion

This dissertation sought to examine the interrelationship between public debt (PD) and several pertinent macroeconomic variables, including social expenditure (SD), the elderly population (IP) and interest rates on 10-year bonds. Additionally, the analysis encompassed other variables such as the inflation rate (INF) and the savings rate (NSP), with a particular focus on Eurozone countries.

The study was prompted by the necessity to comprehend the interrelationships and impacts of these variables on the fiscal sustainability of Eurozone countries, particularly in the context of significant economic volatility and uncertainty, including the aftermath of the economic crises and the global pandemic.

In order to achieve this objective, the analysis utilized various econometric models, including Ordinary Least Squares (OLS) and the dynamic Arellano-Bond Generalized Method of Moments (GMM), to explore the intricate relationships among public debt (DP), social spending (DS), elderly population (PI), and savings (TXj), using the level of variables. A notable finding was the positive correlation between public debt and social spending, suggesting that increased social spending tends to coincide with higher levels of public debt. However, this relationship is complex and can vary significantly based on the prevailing economic conditions and specific policies implemented.

Additionally, the analysis examined the correlation between public debt and savings, as well as between public debt and inflation. In addition, the analysis examined the correlation between public debt and savings, as well as between public debt and inflation. It found that while public debt generally shows a negative correlation with inflation - indicating that moderate inflation can help reduce the real value of debt - a stronger negative correlation was identified between public debt and savings, especially when considering differences.

The first differences of the variables (D_DP, D_DS, D_PI) were also analyzed because, following the initial construction of the econometric models, it was determined that these variables were non-stationary, except for TXj. Consequently, correlation tests were conducted among these differenced variables, as well as a multicollinearity test. The results indicated weak correlations between the variables in differences and TXj, highlighting the absence of strong relationships between them. However, D_PI was significant and positive, while TXj was significant and negative. Initially, the Hausman test indicated that the random effects model was more suitable for the dataset at hand. However, after performing the first differences and applying the fixed effects (FE) and random effects (RE) models again, the Hausman test revealed that the fixed effects model was, in fact, the most

appropriate choice. Moreover, the Arellano-Bond model for the level variables was deemed less suitable, as it showed that public debt does not depend significantly on its past values.

Overall, the analysis indicates that while there is a general positive relationship between social spending and public debt, the dynamics are shaped by a multitude of factors, including economic contexts and policy frameworks. The weak correlations among the differenced variables signal the need for further investigation into the underlying mechanisms that govern these relationships, highlighting the complexities inherent in understanding fiscal dynamics within the Eurozone.

This dissertation makes a significant contribution to the understanding of public debt dynamics in the Eurozone by developing a robust econometric model that identifies key factors influencing public debt. It highlights the importance of dynamic models in panel data and the need to account for unobserved country-specific factors. The findings indicate a positive relationship between public debt and both social spending and the elderly population, while the impact of inflation is minimal. However, the study acknowledges certain limitations, including the short data period and the exclusion of political and institutional variables, which play a crucial role in public debt development. To address demographic changes, the study recommends strategic adjustments such as increasing the retirement age in line with life expectancy, enhancing access to lifelong learning, and promoting responsible fiscal policies. It also suggests that Eurozone countries should adopt immigration policies to counteract the effects of an aging population. Future research could explore long-term fiscal sustainability under various demographic scenarios and the effects of specific policy measures on public debt. Additionally, comparative studies across regions facing similar demographic challenges could provide valuable insights.

In conclusion, this research offers important insights for developing sustainable public policies in the Eurozone by elucidating the complex relationships between macroeconomic variables and public debt. It serves as a reference for future studies on fiscal and macroeconomic variables, advocating for adaptive policies in response to demographic dynamics.

Bibliographical references

[1] Aghion, P., & Howitt, P. (2009). The Economics of Growth. Cambridge, MA: MIT Press.

[2] Akerlof, G. A., & Kranton, R. E. (2010). Identity Economics: How Our Identities Shape Our Work, Wages, and Well-Being. Princeton, NJ: Princeton University Press

[3] Alesina, A., & Ardagna, S. (2010). Large Changes in Fiscal Policy: Taxes Versus Spending. *In* NBER Working Papers, No. 15438.

[4] Blanchard, O. J. (1985). "Debt, Deficits, and Finite Horizons." Journal of Political Economy, 93(2), 223-247. https://doi.org/10.1086/261297

[5] Blanchard, O., & Leigh, D. (2013). Growth Forecast Errors and Fiscal Multipliers. American Economic Review, 103(3), 117-120.

[6] Blanchard, O., Dell'Ariccia, G., & Mauro, P. (2013). Rethinking macroeconomic policy. Journal of Money, Credit and Banking, 45(s2), 273-312.

[7] Blanchard, O. (2019). *Public Debt and Low Interest Rates*. American Economic Review, 109(4), 1197-1229.

[8] Blanchard, O., & Summers, L. H. (2020). Rethinking Fiscal Policy in an Era of Low Interest Rates. *Brookings Papers on Economic Activity*, 2020(2), 1-62.

[9] Bloom, D. E., Canning, D., & Fink, G. (2010). Implications of Population Aging for Economic Growth. *National Bureau of Economic Research* No. 16504.

[10] Bloom, D. E., & Sousa-Poza, A. (2013). The Economics of Ageing*In P. H. Lindert & E. G. L. Fehr (Eds.), Handbook of Social Economics* (pp. 1023-1090). Amsterdam: Elsevier.

[11] Börsch-Supan, A. (2013). Demographic Change, Saving, and Asset Prices: Theory and Evidence. *In R. B. Durlauf & L. E. Blume (Eds.), The New Palgrave Dictionary of Economics (pp. 1-8). London: Palgrave Macmillan.*

[12] Börsch-Supan, A., & Hank, K. (2020). Ageing, Social Security, and the Demographic Dividend Hypothesis: How Does Population Aging Really Affect the Economy? Journal of Population Economics, 33(3), 961-989.

[13] Börsch-Supan, A., Hank, K., & Jürges, H. (2020). *Aging, Health, and Labor Force Participation: A European Perspective*. Mannheim: Mannheim Research Institute for the Economics of Aging.

[14] Buchanan, J. M. (1958). Public Principles of Public Debt: A Defense and Restatement. Richard D. Irwin, Inc.

[15] B., & Schettkat, R. (2005). Marketization of Production and the US-Europe Employment Gap. Oxford University Press.

[16] Bruegel. (2022). The implications for public debt of high inflation and monetary tightening. Retrieved from Bruegel

[17] DellaPergola, S. (2000). Jewish Demographic Policies: Population Trends and Options in Israel and in the Diaspora. Jerusalem: The Hebrew University of Jerusalem.

[18] Draghi, M. (2012). Addressing the challenges for the euro area. Speech at the Global Investment Conference in London.

[19] Draghi, M. (2014). *Monetary Policy in the Euro Area*. European Central Bank.

[20] Draghi, M. (2014). Unemployment in the euro area [Speech]. Annual central bank symposium in Jackson Hole, Wyoming, 22 August 2014. European Central Bank. https://www.ecb.europa.eu/press/key/date/2014/html/sp140822.en.html

[21] Elmendorf, D. W., & Sheiner, L. (2000). Should America Save for Its Old Age? Fiscal Policy, Population Aging, and National Saving. Journal of Economic Perspectives, 14(3), 57-74.

[22] European Central Bank (ECB). Annual Reports

[23] European Central Bank. (2020). "Monetary Policy in Times of Crisis." Retrieved from ECB.

[24] European Commission. (2020). "Next Generation EU: The EU Recovery Plan." Retrieved from European Commission.

[25] European Commission. (2021). *The 2021 Ageing Report: Economic and Budgetary Projections for the EU Member States (2019–2070)*. Brussels: European Commission.

[26] Fama, E. F. (1970). Efficient Capital Markets: A Review of Theory and Empirical Work. The Journal of Finance, 25(2), 383-417.

[27] Favero, C. A., & Giavazzi, F. (2007). Debt and the Effects of Fiscal Policy. NBER Chapters, 0111(3), 1-22.

[28] Freeman, R. B., & Schettkat, R. (2005). Marketization of Production and the US-Europe Employment Gap. NBER Working Paper No. 11880. National Bureau of Economic Research. Available at: NBER

[29] Gruber, J., & Wise, D. A. (1999). Social Security and Retirement around the World. University of Chicago Press.

[30] International Monetary Fund (IMF). (2014). *Portugal: Staff Report for the 2014 Article IV Consultation*. Washington, DC: IMF.

[31] Kahanec, M., & Kurekova, L. (2017). *The Economics of Migration: The Case of the EU*. Journal of European Economy, 16(1), 21-36.

[32] Kamiguchi, A., & Tamai, T. (2019). "Public Investment, Public Debt, and Population Aging under the Golden Rule of Public Finance." Journal of Macroeconomics, 60, 110-122.

[33] Kamiguchi, T., & Tamai, H. 2019. Population Aging and Public Investment: An Analysis of the Golden Rule of Public Finance. The Japanese Economic Review, 70(2), 245-263

[34] Krugman, P. (2012). End this depression now!. WW Norton & Company.

[35] Krugman, P. (2013). *End This Depression Now!*. W.W. Norton & Company

[36] Lagarde, C. (2017). Building a More Resilient and Inclusive Global Economy. Speech delivered at the 2017 Spring Meetings of the IMF and the World Bank Group, Washington, D.C., April 12, 2017. Available at: https://www.imf.org/en/News/Articles/2017/04/12/sp041217-building-a-more-resilient-and-inclusive-global-economy

[37] Lee, R., & Mason, A. (2011). Population Aging and the Generational Economy: A Global Perspective. Edward Elgar Publishing.

[38] Lindert, P. H. (2004). Growing Public: Social Spending and Economic Growth Since the Eighteenth Century.

[39] Lucas, R. E. (1972). Expectations and the neutrality of money. Journal of Economic Theory, 4(2), 103-124.

[40] Lucas, R. E. (1976). "Econometric Policy Evaluation: A Critique." In *Carnegie-Rochester Conference Series on Public Policy* (Vol. 1, pp. 19-46).

[41] Lutz, W., et al. (1997). Demographic Metabolism: A Predictive Theory of Socioeconomic Change. Population and Development Review, 23(2), 221-258.

[42] Mankiw, N. G. (2001). "The Inexorable and Universal Law of 2 Percent." *The Journal of Economic Perspectives*, 15(2), 177-198.

[43] Mankiw, N. G. (2001). Macroeconomics (5th ed.). Worth Publishers.

[44] Modigliani, F., & Brumberg, R. (1954). Utility analysis and the consumption function: An interpretation of cross-section data. In K. Kurihara (Ed.), Post-Keynesian Economics (pp. 388-436). New Brunswick, NJ: Rutgers University Press.

[45] OECD. (2019). *Pensions at a Glance 2019: OECD and G20 Indicators*. Paris: OECD Publishing.

[46] OECD. (2020). *Family Policy in Germany: An Overview*. Paris: OECD Publishing.

[47] OECD (2021). Pensions at a Glance 2021: OECD and G20 Indicators. Paris: OECD Publishing.

[48] OECD. (2021). Long term interest rates. OECD Data Indicators. Retrieved from OECD.

[49] OECD. (2012). Saving rate. OECD Data Indicators. Retrieved from OECD.

[50] OECD. (2012-2021). National accounts - aggregate data. OECD Data Indicators. Retrieved from OECD.

[51] Piketty, T. (2014). Capital in the Twenty-First Century. Cambridge, MA: Harvard University Press.

[52] Poot, J., & de Haan, J. (Eds.). (2018). Migration and Human Capital. Cheltenham, UK: Edward Elgar Publishing.

[53] Prammer, D. (2019). "How Does Population Aging Impact Personal Income Taxes and Social Security Contributions?" Journal of Economics of Ageing, 14, 100186.

[54] Prammer, D. 2019. Aging and Public Finances: A Long-term Perspective. OECD Economic Policy Papers, No. 25. Paris: OECD Publishing.

[55] Razin, A., Sadka, E., & Swagel, P. (2002). "The Aging Population and the Size of the Welfare State." Journal of Political Economy, 110(4), 900-918.

[56] Razin, A., Sadka, E., & Swagel, P. 2002. The aging population and the financial sustainability of the welfare state. Journal of Population Economics, 15(1), 135-153

[57] Reinhart, C. M., & Rogoff, K. S. (2009). This time is different: Eight centuries of financial folly. Princeton University Press.

[58] Reinhart, C., & Rogoff, K. (2010). Growth in a Time of Debt. American Economic Review , 100(2), 573-578.

[59] Samuelson, P. A. (1958). An exact consumption-loan model of interest with or without the social contrivance of money. The Journal of Political Economy, 66(6), 467-482.

[60] Sargent, T. J. (1993). *Bounded Rationality in Macroeconomics*. New York: Oxford University Press.

[61] Schwab, K. (2017). *The Fourth Industrial Revolution*. New York: Crown Business.

[62] Sobotka, T., et al. (2011). The Future of Fertility in Europe: Exploring the Influence of Circumstances, Policies, and Values. Springer.

[63] Stiglitz, J. (2016). *The Euro: How a Common Currency Threatens the Future of Europe*. W.W. Norton & Company

[64] Trichet, J.-C. (2012). *Central Banking in the Euro Area*. ECB.

[65] Werding, M. (2016). Demographic Change, Fiscal Policy and Economic Growth: Implications for the Netherlands and Other Industrial Countries. Springer.

Annex A

Annex A - Database for each eurozone country for the variables studied and the period studied

Table A.16 - Differencing non-stationary variables: DS, PI and DP

```
. gen D_DS = D.DS
(16 missing values generated)

. gen D_PI = D.PI
(16 missing values generated)

. gen D_DP = D.DP
(16 missing values generated)
```

Source: Stata

Table A.22 - Fixed effects model for variables D_DP, D_DS, D_PI and TXj

```
. xtreg D_DP D_DS D_PI TXj, fe

Fixed-effects (within) regression               Number of obs      =       144
Group variable: Country                         Number of groups   =        16

R-squared:                                      Obs per group:
     Within  = 0.1391                                         min =         9
     Between = 0.0515                                         avg =       9.0
     Overall = 0.0289                                         max =         9

                                                F(3, 125)          =      6.73
corr(u_i, Xb) = -0.6464                         Prob > F           =    0.0003
```

D_DP	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
D_DS	2.004767	2.101807	0.95	0.342	-2.154969	6.164503
D_PI	111.2027	41.49973	2.68	0.008	29.06957	193.3358
TXj	-9.016478	2.444268	-3.69	0.000	-13.85399	-4.178969
_cons	-24.30449	12.62282	-1.93	0.056	-49.28662	.6776412
sigma_u	23.815666					
sigma_e	37.003531					
rho	.29290027	(fraction of variance due to u_i)				

```
F test that all u_i=0: F(15, 125) = 1.93                     Prob > F = 0.0255
```

Source: Stata

Table A.23 - Random effects model for variables D_DP, D_DS, D_PI and TXj

```
. xtreg D_DP D_DS D_PI TXj, re

Random-effects GLS regression                   Number of obs      =       144
Group variable: Country                         Number of groups   =        16

R-squared:                                      Obs per group:
     Within  = 0.1040                                         min =         9
     Between = 0.0113                                         avg =       9.0
     Overall = 0.0500                                         max =         9

                                                Wald chi2(3)       =      8.69
corr(u_i, X) = 0 (assumed)                      Prob > chi2        =    0.0337
```

D_DP	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
D_DS	2.916702	2.108921	1.38	0.167	-1.216706	7.050111
D_PI	18.66891	24.25408	0.77	0.441	-28.86821	66.20602
TXj	-4.557522	1.919887	-2.37	0.018	-8.320432	-.7946119
_cons	-2.522882	8.226784	-0.31	0.759	-18.64708	13.60132
sigma_u	6.8299856					
sigma_e	37.003531					
rho	.03294609	(fraction of variance due to u_i)				

Source: Stata

Table A.26 – Correlation between differentiated public debt (D_DP) and differentiated inflation (D_INF)

```
. pwcorr D_DP D_INF , sig
```

	D_DP	D_INF
D_DP	1.0000	
D_INF	-0.0072	1.0000
	0.9321	

Source: Eurostat

Table A.28 - Correlation between differentiated public debt (D_DP) and differentiated inflation (D_NSP)

```
. pwcorr D_DP D_NSP , sig
```

	D_DP	D_NSP
D_DP	1.0000	
D_NSP	-0.1532	1.0000
	0.0668	

Source: Eurostat

Table A.29 - Austria Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
AT	2012	29,10	17,80	81,90	2,37	0,68	2,60	8,19
AT	2013	29,60	18,10	81,30	2,01	0,03	2,10	7,55
AT	2014	29,70	18,30	84,00	1,49	0,66	1,50	8,00
AT	2015	29,80	18,50	84,90	0,75	1,01	0,80	7,76
AT	2016	29,70	18,40	82,80	0,38	1,99	1,00	9,29
AT	2017	29,30	18,50	78,50	0,58	2,26	2,20	8,40
AT	2018	29,10	18,70	74,10	0,69	2,43	2,10	8,78
AT	2019	29,30	18,80	70,60	0,06	1,45	1,50	9,51
AT	2020	34,00	19,00	82,90	-0,22	-6,63	1,40	9,32
AT	2021	32,90	19,20	82,50	-0,09	4,24	2,80	9,60

Source: Eurosta

Table A.30 - Belgium Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
BE	2012	29,70	17,40	104,80	3,00	0,74	2,60	5,17
BE	2013	30,00	17,60	105,50	2,41	0,46	1,20	4,72
BE	2014	30,00	17,80	107,00	1,71	1,58	0,50	5,30
BE	2015	29,80	18,10	105,20	0,84	2,04	0,60	6,04
BE	2016	29,20	18,20	105,00	0,48	1,27	1,80	6,06
BE	2017	28,80	18,50	102,00	0,72	1,62	2,20	6,49
BE	2018	28,70	18,70	99,90	0,80	1,79	2,30	5,77
BE	2019	28,70	18,90	97,60	0,19	2,24	1,20	6,37
BE	2020	32,70	19,10	111,90	-0,15	-5,30	0,40	5,59
BE	2021	30,00	19,30	107,90	-0,01	6,93	3,20	7,77

Source: Eurostat

Table A.31 - Germany Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
DE	2012	28,90	20,70	80,70	1,50	0,42	2,20	8,89
DE	2013	29,20	20,80	78,30	-0,01	0,44	1,60	8,49
DE	2014	29,10	20,90	75,30	1,50	2,21	0,80	9,83
DE	2015	29,40	21,00	71,90	1,57	1,49	0,70	10,46
DE	2016	29,60	21,10	69,00	1,16	2,23	0,40	10,83
DE	2017	29,50	21,20	65,20	0,50	2,68	1,70	11,21
DE	2018	29,70	21,40	61,90	0,09	0,98	1,90	11,89
DE	2019	30,00	21,50	59,60	0,32	1,08	1,40	11,84
DE	2020	32,80	21,80	68,80	0,40	-3,83	0,40	9,78
DE	2021	31,90	22,00	69,00	-0,25	3,16	3,20	11,55

Source: Eurostat

Table A.32 – Spain Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
ES	2012	25,70	17,40	90,00	5,85	-2,96	2,40	2,55
ES	2013	25,90	17,70	100,50	4,56	-1,40	1,50	3,32
ES	2014	25,50	18,10	105,10	2,72	1,40	-0,20	3,66
ES	2015	24,70	18,50	103,30	1,74	3,84	-0,60	5,36
ES	2016	23,80	18,70	102,70	1,39	3,04	-0,30	6,43
ES	2017	23,40	19,00	101,80	1,56	2,98	2,00	6,85
ES	2018	23,60	19,20	100,40	1,42	2,28	1,70	7,12
ES	2019	24,10	19,40	98,20	0,66	1,98	0,80	7,71
ES	2020	30,10	19,60	120,30	0,38	-11,17	-0,30	3,69
ES	2021	28,10	19,80	116,80	0,35	6,40	3,00	5,45

Source: Eurostat

Table A.33 – Eurozone Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
EZ	2012	29,40	18,70	91,30	3,05	-0,85	2,50	3,13
EZ	2013	29,80	19,00	93,30	3,01	-0,22	1,30	3,77
EZ	2014	29,70	19,30	93,50	2,28	1,40	0,40	4,45
EZ	2015	29,40	19,60	91,60	1,27	2,05	0,20	5,20
EZ	2016	29,20	19,90	90,50	0,93	1,87	0,20	5,83
EZ	2017	28,80	20,20	88,20	1,17	2,63	1,50	6,66
EZ	2018	28,70	20,40	86,20	1,26	1,79	1,80	6,80
EZ	2019	28,80	20,70	84,20	0,58	1,59	1,20	7,08
EZ	2020	32,80	21,00	97,30	0,21	-6,11	0,30	4,49
EZ	2021	31,00	21,20	94,80	0,20	5,96	2,60	6,78

Source: Eurostat

Table A.34 – Finland Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
FI	2012	29,90	18,10	57,70	1,88	-1,40	3,20	2,19
FI	2013	31,00	18,80	60,60	1,86	-0,90	2,20	1,13
FI	2014	31,70	19,40	64,50	1,45	-0,36	1,20	1,54
FI	2015	31,80	19,90	68,30	0,72	0,54	-0,20	1,95
FI	2016	31,60	20,50	68,00	0,37	2,81	0,40	2,55
FI	2017	30,50	20,90	66,00	0,55	3,19	0,80	4,76
FI	2018	30,10	21,40	64,80	0,66	1,14	1,20	4,85
FI	2019	30,10	21,80	64,90	0,07	1,22	1,10	4,87
FI	2020	31,90	22,30	74,70	-0,22	-2,35	0,40	5,60
FI	2021	31,00	22,70	75,60	-0,10	2,84	2,10	5,39

Source: Eurostat

Table A.35 – France Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
FR	2012	33,80	17,10	91,70	2,54	0,31	2,20	3,44
FR	2013	34,20	17,60	94,70	2,20	0,58	1,00	3,28
FR	2014	34,50	18,00	96,30	1,67	0,96	0,60	3,45
FR	2015	34,20	18,40	97,10	0,84	1,11	0,10	4,38
FR	2016	34,30	18,90	98,00	0,47	1,10	0,30	4,09
FR	2017	34,00	19,30	98,50	0,81	2,29	1,20	4,71
FR	2018	33,70	19,70	98,20	0,78	1,87	2,10	4,97
FR	2019	33,40	20,00	97,90	0,13	1,84	1,30	5,21
FR	2020	38,00	20,40	114,90	-0,14	-7,54	0,50	0,69
FR	2021	35,80	20,70	113,00	0,01	6,44	2,10	3,86

Source: Eurostat

Table A.36 – Greece Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
GR	2012	28,60	19,70	162,00	22,81	-7,09	1,00	-10,10
GR	2013	26,60	20,10	178,20	10,05	-2,52	-0,90	-7,73
GR	2014	26,10	20,50	180,30	6,93	0,48	-1,40	-6,78
GR	2015	26,30	20,90	176,70	9,67	-0,20	-1,10	-6,06
GR	2016	26,60	21,30	180,50	8,36	-0,49	0,00	-5,73
GR	2017	25,70	21,50	179,50	5,98	1,09	1,10	-5,86
GR	2018	25,50	21,80	186,40	4,19	1,67	0,80	-5,68
GR	2019	25,40	22,00	180,60	2,59	1,88	0,50	-4,55
GR	2020	29,50	22,30	207,00	1,27	-9,32	-1,30	-9,54
GR	2021	27,10	22,50	195,00	0,89	8,38	0,60	-5,65

Source: Eurostat

Table A.37 – Ireland Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
IE	2012	24,20	11,90	119,90	-0,51	-0,13	1,90	1,28
IE	2013	23,00	12,20	120,10	-0,37	1,17	0,50	5,61
IE	2014	21,30	12,60	104,00	2,37	8,83	0,30	8,91
IE	2015	16,20	12,90	76,50	1,18	24,48	0,00	8,28
IE	2016	16,10	13,20	74,40	0,74	1,77	-0,20	8,95
IE	2017	15,10	13,50	67,40	0,80	9,31	0,30	9,21
IE	2018	14,20	13,80	62,90	0,95	8,47	0,70	8,74
IE	2019	13,70	14,10	57,10	0,33	5,30	0,90	9,68
IE	2020	15,30	14,40	58,10	-0,06	6,62	-0,50	8,25
IE	2021	13,70	14,80	54,40	0,06	15,13	2,40	10,86

Source: Eurostat

Table A.38 – Italy Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
IT	2012	28,90	20,80	126,50	5,49	-2,98	3,30	-0,71
IT	2013	29,40	21,20	132,50	4,32	-1,84	1,20	-0,32
IT	2014	29,60	21,40	135,40	2,89	0,00	0,20	0,66
IT	2015	29,70	21,70	135,30	1,71	0,78	0,10	0,40
IT	2016	29,20	22,00	134,80	1,49	1,29	-0,10	2,42
IT	2017	28,90	22,30	134,20	2,11	1,67	1,30	3,00
IT	2018	28,80	22,60	134,50	2,61	0,93	1,20	3,56
IT	2019	29,20	22,90	134,20	1,95	0,48	0,60	3,89
IT	2020	34,30	23,20	155,00	1,17	-8,97	-0,10	2,44
IT	2021	31,80	23,50	147,10	0,81	8,31	1,90	5,94

Source: Eurostat

Table A.39 – Lithuania Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
LT	2012	16,30	18,10	39,70	4,83	3,84	3,20	4,98
LT	2013	15,40	18,20	38,70	3,83	3,55	1,20	7,97
LT	2014	15,30	18,20	40,50	2,79	3,54	0,20	9,92
LT	2015	15,70	18,40	42,50	1,38	2,02	-0,70	5,46
LT	2016	15,40	18,60	39,70	0,90	2,52	0,70	4,84
LT	2017	15,10	18,80	39,10	0,31	4,28	3,70	7,05
LT	2018	15,80	19,10	33,70	0,31	3,99	2,50	8,19
LT	2019	16,50	19,40	35,80	0,31	4,67	2,20	8,72
LT	2020	19,50	19,50	46,20	0,22	-0,02	1,10	8,76
LT	2021	18,50	19,60	43,40	0,16	6,28	4,60	8,81

Source: Eurostat

Table A.40 – Luxembourg Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
LU	2012	21,20	14,00	20,80	1,82	1,65	2,90	14,00
LU	2013	21,40	14,00	22,40	1,85	3,17	1,70	11,24
LU	2014	21,10	14,10	21,90	1,34	2,62	0,70	13,10
LU	2015	20,70	14,20	21,10	0,37	2,27	0,10	6,48
LU	2016	20,30	14,20	19,60	0,25	4,98	0,00	8,20
LU	2017	21,00	14,20	21,80	0,54	1,32	2,10	10,24
LU	2018	21,40	14,30	20,90	0,50	1,22	2,00	8,95
LU	2019	21,70	14,40	22,40	-0,12	2,92	1,60	5,97
LU	2020	24,30	14,50	24,60	-0,41	-0,91	0,00	8,95
LU	2021	21,90	14,60	24,50	-0,36	7,17	3,50	7,96

Source: Eurostat

Table A.41 - The Netherlands Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
NL	2012	31,40	16,20	66,20	1,93	-1,03	2,80	9,04
NL	2013	31,50	16,80	67,70	1,96	-0,13	2,60	9,31
NL	2014	31,30	17,30	67,90	1,45	1,42	0,30	9,54
NL	2015	30,30	17,80	64,70	0,69	1,96	0,20	10,76
NL	2016	29,90	18,20	61,90	0,29	2,19	0,10	10,78
NL	2017	29,30	18,50	57,00	0,52	2,91	1,30	12,84
NL	2018	28,90	18,90	52,40	0,58	2,36	1,60	13,58
NL	2019	28,80	19,20	48,60	-0,07	1,96	2,70	12,38
NL	2020	32,80	19,50	54,70	-0,38	-3,89	1,10	9,17
NL	2021	30,80	19,80	51,70	-0,33	6,19	2,80	16,40

Source: Eurostat

Table A.42 – Portugal Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
PT	2012	26,40	19,00	129,00	10,55	-4,06	2,80	-3,99
PT	2013	27,60	19,40	131,40	6,29	-0,92	0,40	-1,71
PT	2014	26,90	19,90	132,90	3,75	0,79	-0,20	-2,28
PT	2015	25,70	20,30	131,20	2,42	1,79	0,50	-1,40
PT	2016	25,10	20,70	131,50	3,17	2,02	0,60	-0,76
PT	2017	24,60	21,10	126,10	3,05	3,51	1,60	0,95
PT	2018	24,00	21,50	121,50	1,84	2,85	1,20	0,99
PT	2019	24,00	21,80	116,60	0,76	2,68	0,30	0,98
PT	2020	27,50	22,10	134,90	0,42	-8,30	-0,10	-1,79
PT	2021	26,80	22,40	124,50	0,30	5,74	0,90	0,05

Source: Eurostat

Table A.43 – Slovenia Database

Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
SI	2012	24,70	16,80	536,00	5,81	-2,64	2,80	-1,44
SI	2013	24,60	17,10	70,00	5,81	-1,03	1,90	0,76
SI	2014	23,90	17,50	80,30	3,27	2,77	0,40	3,81
SI	2015	23,80	17,90	82,60	1,71	2,21	-0,80	2,50
SI	2016	23,20	18,40	78,50	1,15	3,19	-0,20	3,25
SI	2017	22,60	18,90	74,20	0,96	4,82	1,60	7,08
SI	2018	22,20	19,40	70,30	0,93	4,45	1,90	8,69
SI	2019	22,20	19,80	65,40	0,28	3,52	1,70	8,33
SI	2020	26,20	20,20	79,60	0,08	-4,24	-0,30	7,97
SI	2021	25,10	20,70	74,40	0,07	8,23	2,00	6,22

Source: Eurostat

Table A.44 – Slovakia Database

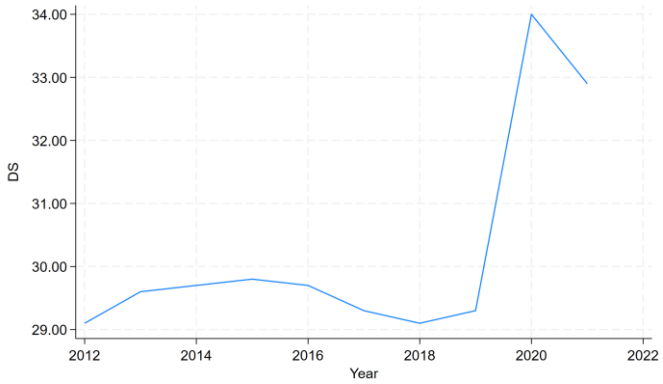
Country_num	Year	DS	PI	DP	TXj	GDP	INF	NSP
SK	2012	17,80	12,80	51,70	4,57	1,30	3,70	5,66
SK	2013	18,20	13,10	54,70	3,34	0,60	1,50	6,23
SK	2014	18,40	13,50	53,50	2,51	2,70	-0,10	6,84
SK	2015	17,90	14,00	51,70	0,96	5,20	-0,30	6,92
SK	2016	18,30	14,40	52,30	0,53	1,90	-0,50	4,01
SK	2017	18,20	15,00	51,50	0,83	2,90	1,40	4,94
SK	2018	17,90	15,50	49,40	0,90	4,00	2,50	5,81
SK	2019	17,80	16,00	48,00	0,34	2,50	2,80	3,74
SK	2020	19,60	16,60	58,80	-0,06	-3,30	2,00	2,29
SK	2021	19,40	17,10	61,10	0,00	4,80	2,80	0,93

Source: Eurostat

Annex B

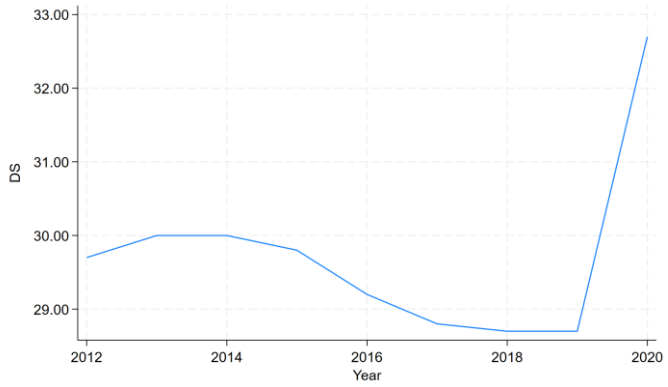
Annex B.1 - Evolution of DS in each Eurozone country

Figure B.8 - Evolution of DS in Austria



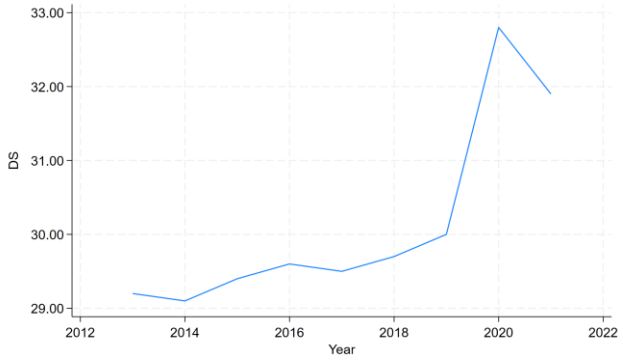
Source: Eurostat; Stata

Figure B.9 - Evolution of DS in Belgium



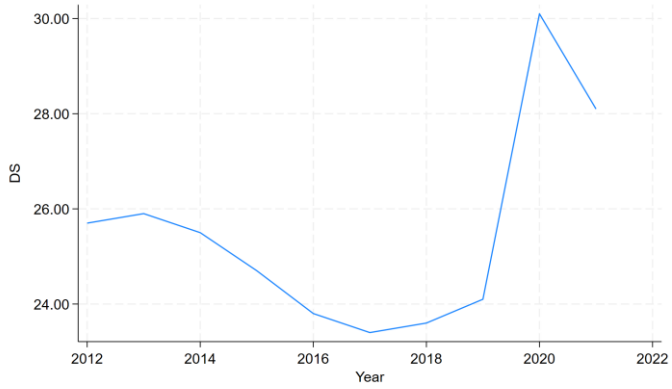
Source: Eurostat; Stata

Figure B.10 - Evolution of DS in Germany



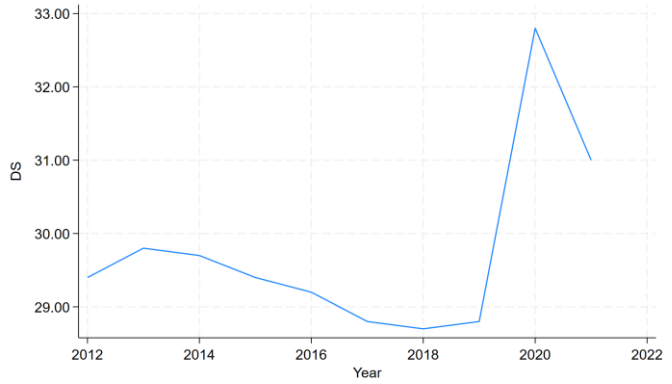
Source: Eurostat; Stata

Figure B.11 - Evolution of DS in Spain



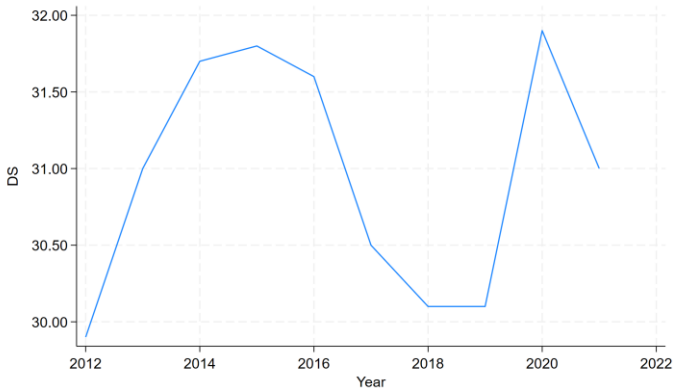
Source: Eurostat; Stata

Figure B.12 - Evolution of DS in the Eurozone



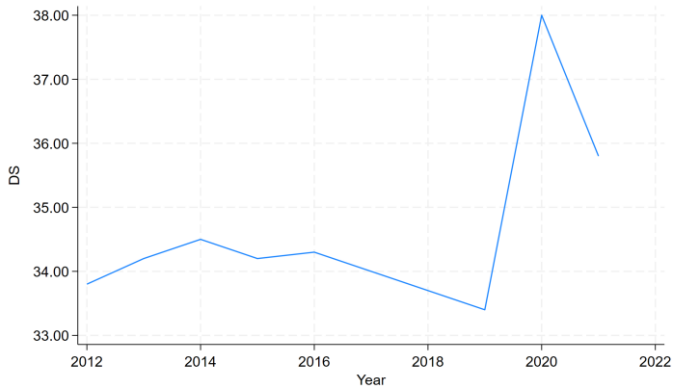
Source: Eurostat; Stata

Figure B.13 - Evolution of DS in Finland



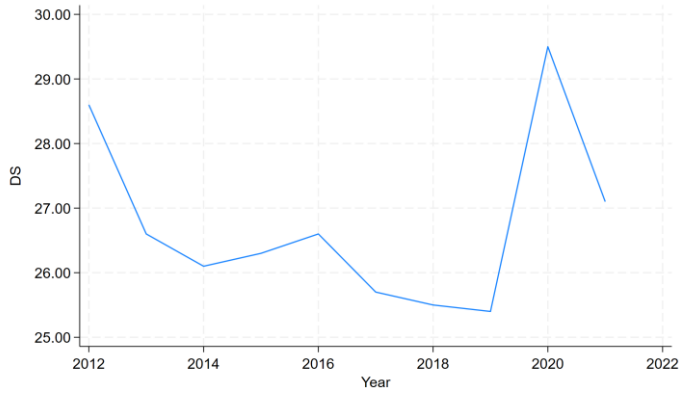
Source: Eurostat; Stata

Figure B.14 - Evolution of DS in France



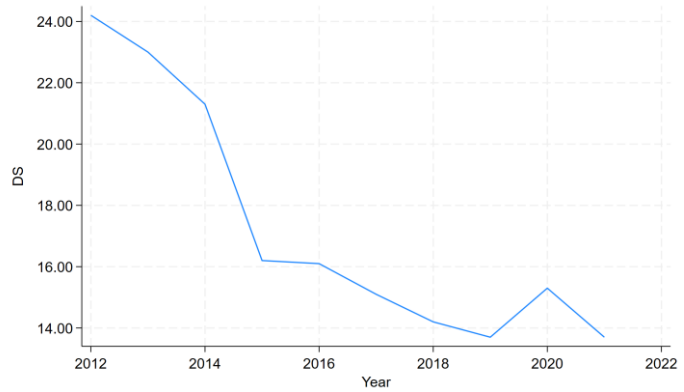
Source: Eurostat; Stata

Figure B.15 - Evolution of DS in Greece



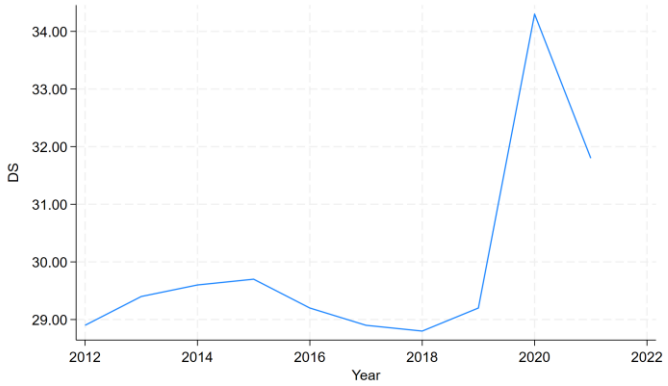
Source: Eurostat; Stata

Figure B.16 - Evolution of DS in Ireland



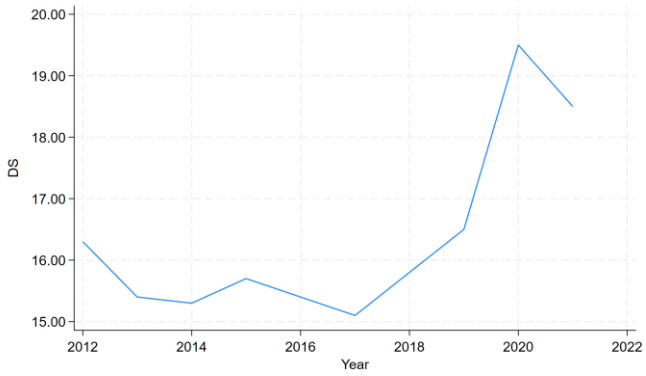
Source: Eurostat; Stata

Figure B.17 - Evolution of DS in Italy



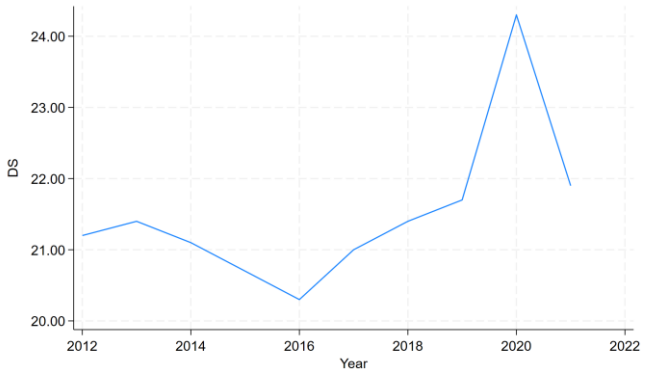
Source: Eurostat; Stata

Figure B.18 - Evolution of DS in Lithuania



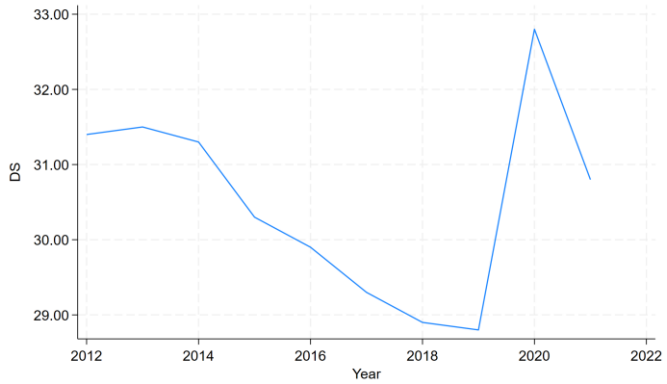
Source: Eurostat; Stata

Figure B.19 - Evolution of DS in Luxembourg



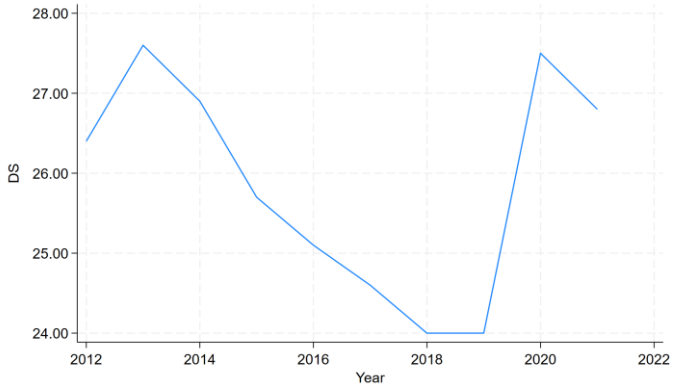
Source: Eurostat; Stata

Figure B.20 - Evolution of DS in the Netherlands



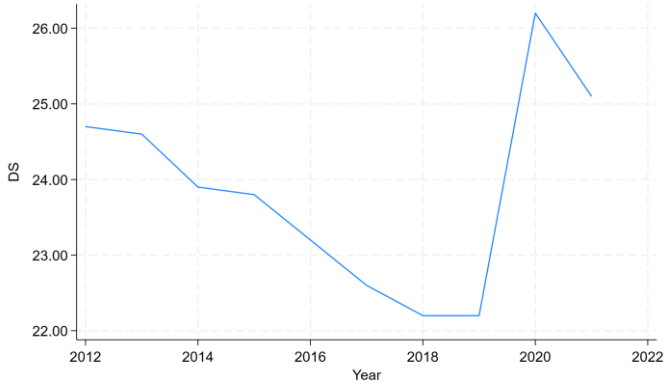
Source: Eurostat; Stata

Figure B.21 - Evolution of DS in Portugal



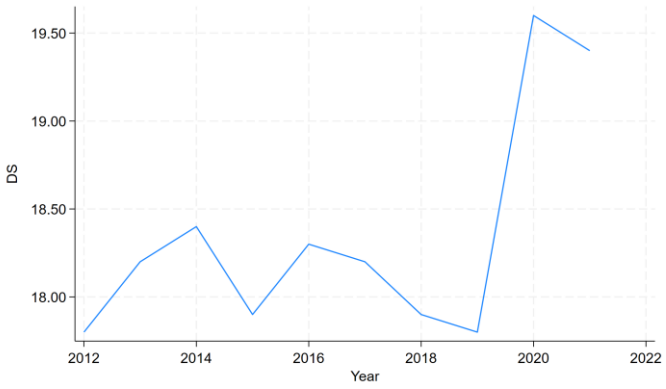
Source: Eurostat; Stata

Figure B.22 - Evolution of DS in Slovenia



Source: Eurostat; Stata

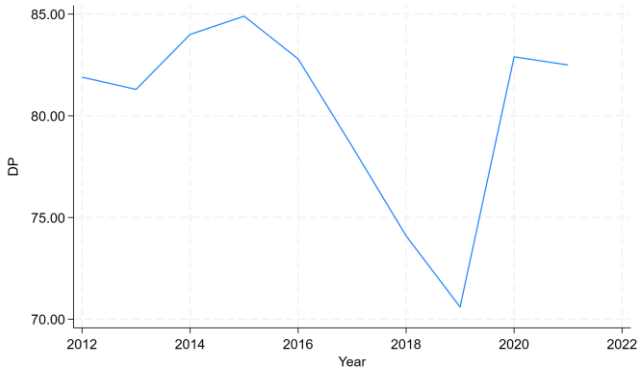
Figure B.23 - Evolution of DS in Slovakia



Source: Eurostat; Stata

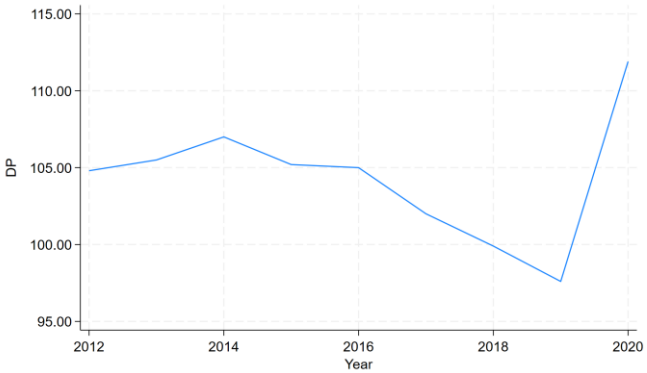
Annex B.2 - Evolution of DP in each Eurozone country

Figure B.24 - Evolution of DP in Austria



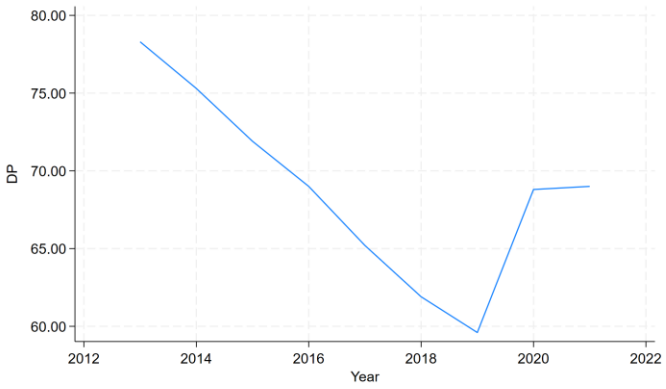
Source: Eurostat; Stata

Figure B.25 - Evolution of DP in Belgium



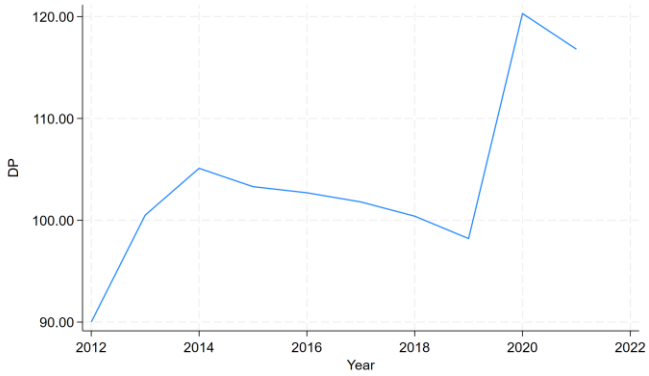
Source: Eurostat; Stata

Figure B.26 - Evolution of DP in Germany



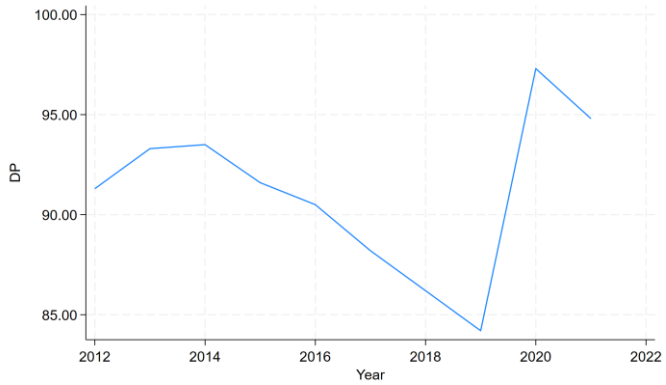
Source: Eurostat; Stata

Figure B.27 - Evolution of DP in Spain



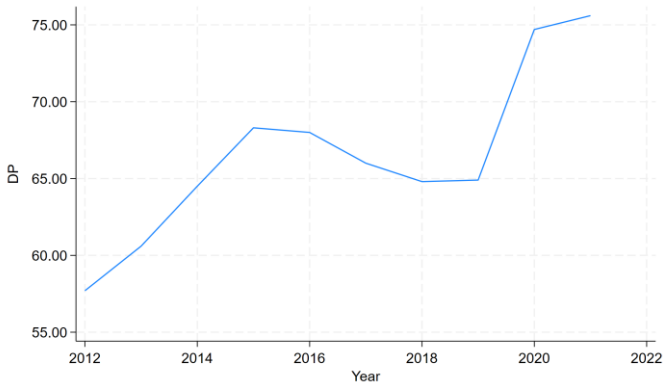
Source: Eurostat; Stata

Figure B.28 - Evolution of DP in the Euro Zone



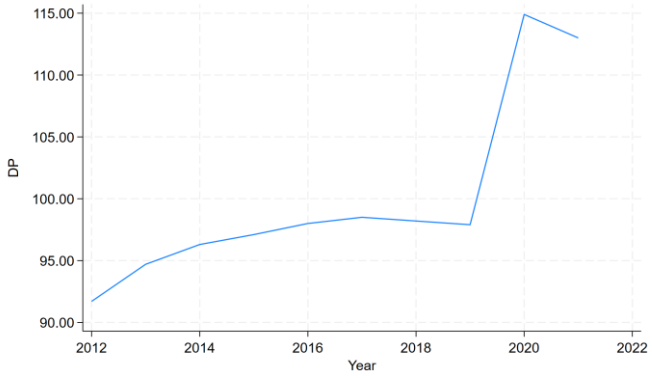
Source: Eurostat; Stata

Figure B.29 - Evolution of DP in Finland



Source: Eurostat; Stata

Figure B.30 - Evolution of DP in France

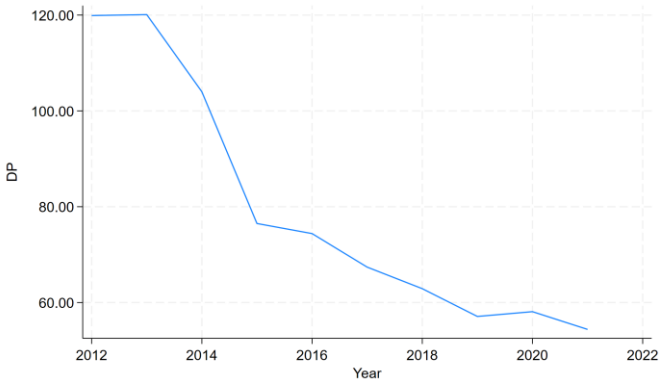


Source: Eurostat; Stata

Figure B.31 - Evolution of DP in Greece

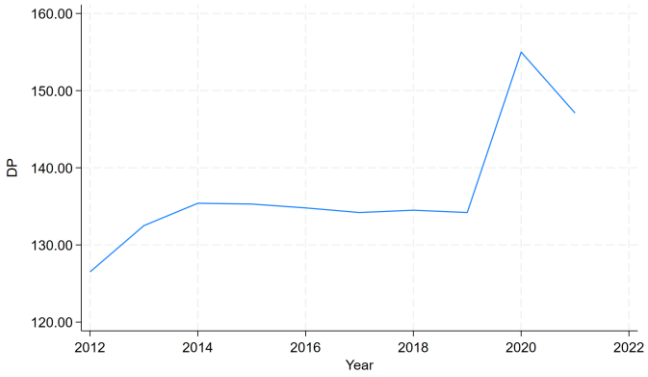
Source: Eurostat; Stata

Figure B.32 - Evolution of DP in Ireland



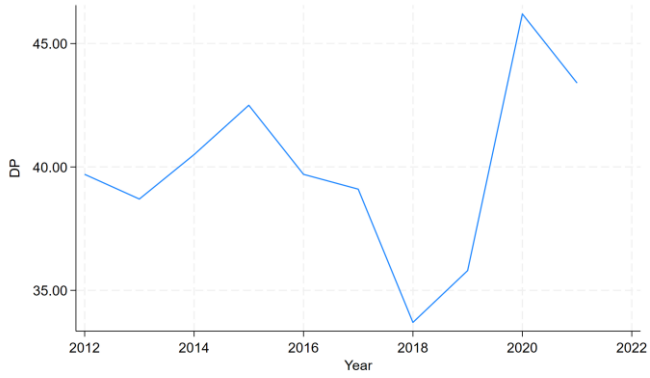
Source: Eurostat; Stata

Figure B.33 - Evolution of DP in Italy



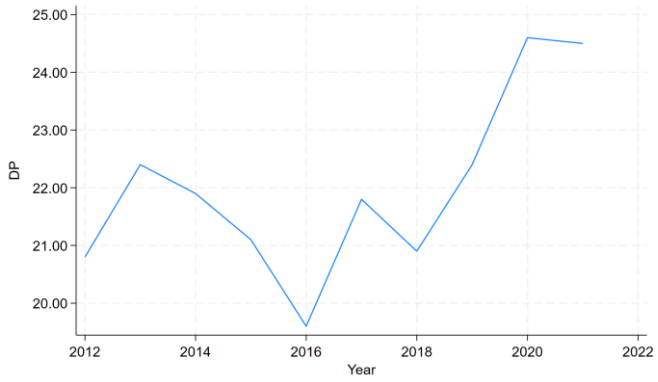
Source: Eurostat; Stata

Figure B.34 - Evolution of DP in Lithuania



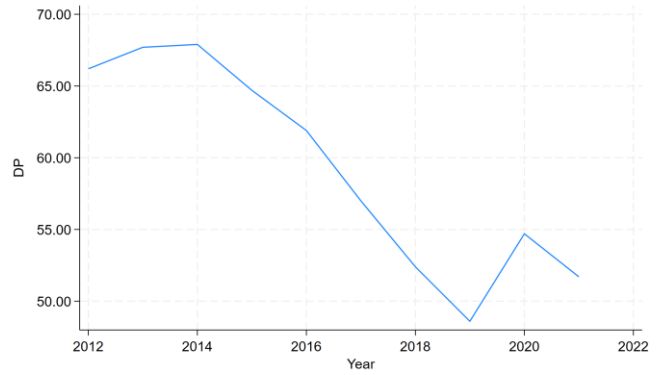
Source: Eurostat; Stata

Figure B.35 - Evolution of DP in Luxembourg



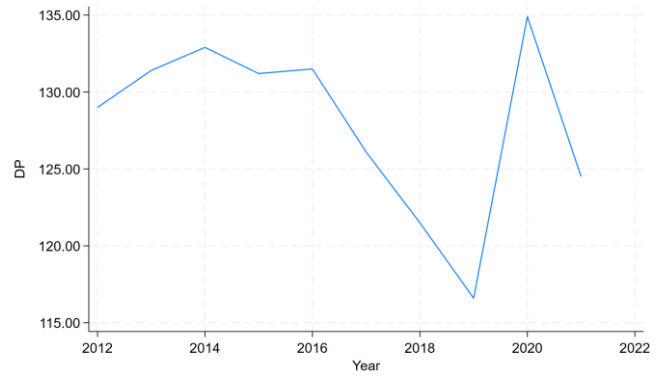
Source: Eurostat; Stata

Figure B.36 - Evolution of DP in the Netherlands



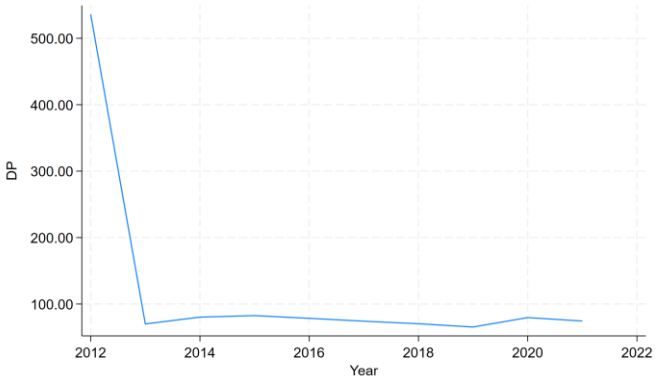
Source: Eurostat; Stata

Figure B.37 - Evolution of DP in Portugal



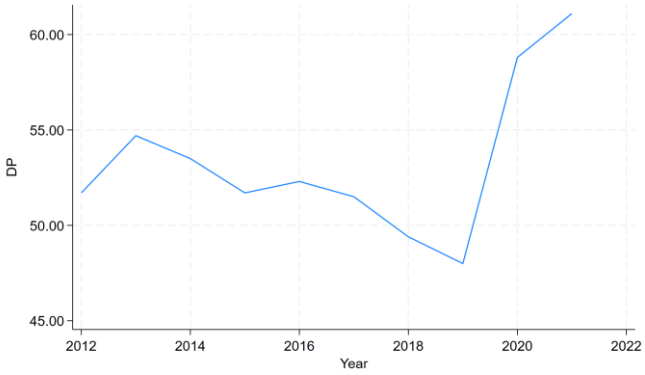
Source: Eurostat; Stata

Figure B.38 - Evolution of DP in Slovenia



Source: Eurostat; Stata

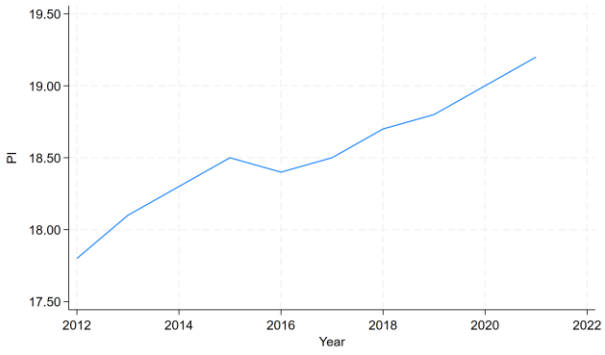
Figure B.39 - Evolution of DP in Slovakia



Source: Eurostat; Stata

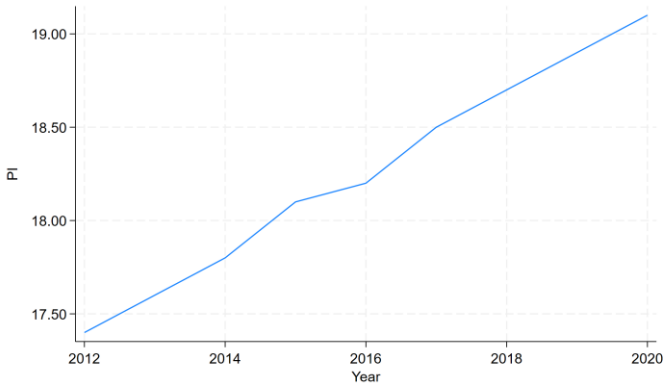
Annex B.3 - Evolution of PI in each Eurozone country

Figure B.40 - Evolution of PI in Austria



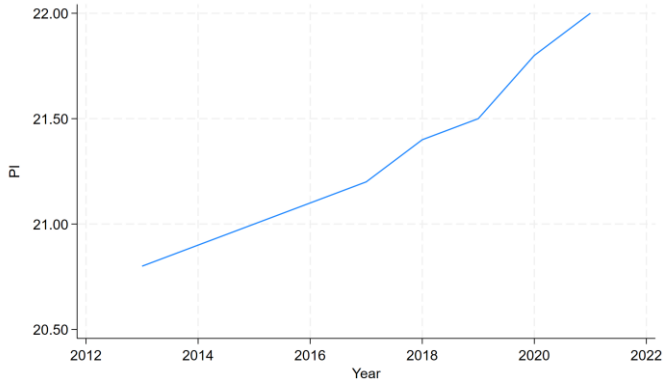
Source: Eurostat; Stata

Figure B.41 - Evolution of PI in Belgium



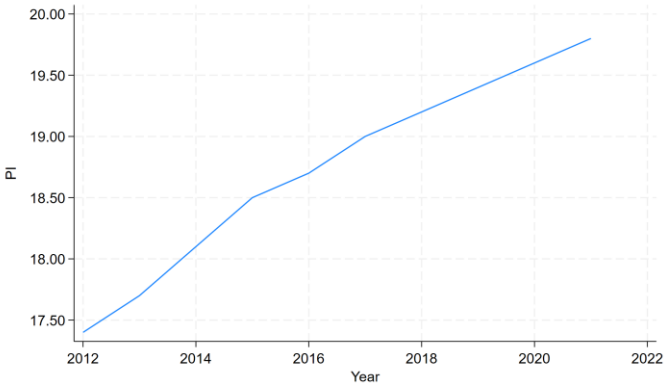
Source: Eurostat; Stata

Figure B.42 - Evolution of PI in Germany



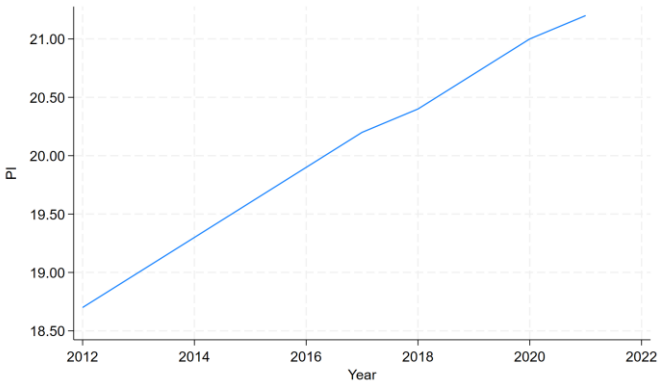
Source: Eurostat; Stata

Figure B.43 - Evolution of PI in Spain



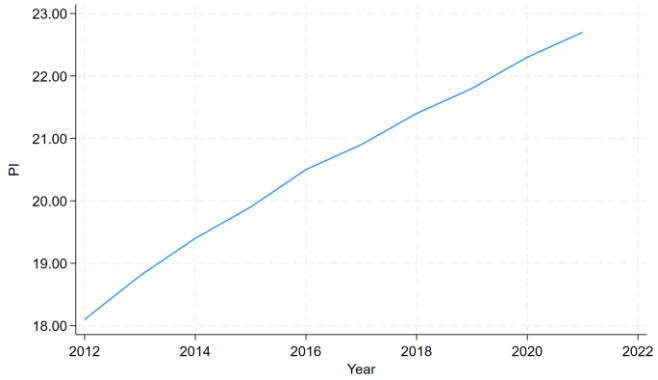
Source: Eurostat; Stata

Figure B.44 - Evolution of PI in Eurozone



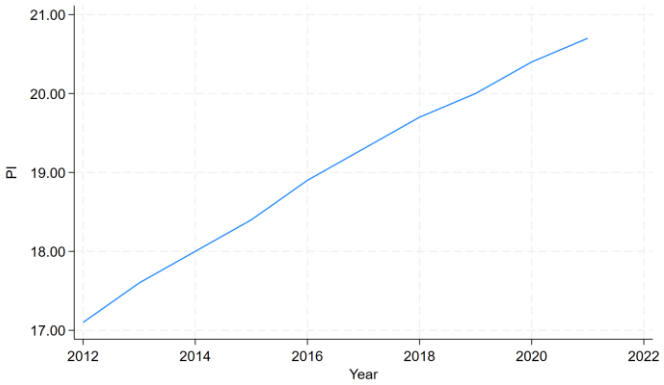
Source: Eurostat; Stata

Figure B.45 - Evolution of PI in Finland



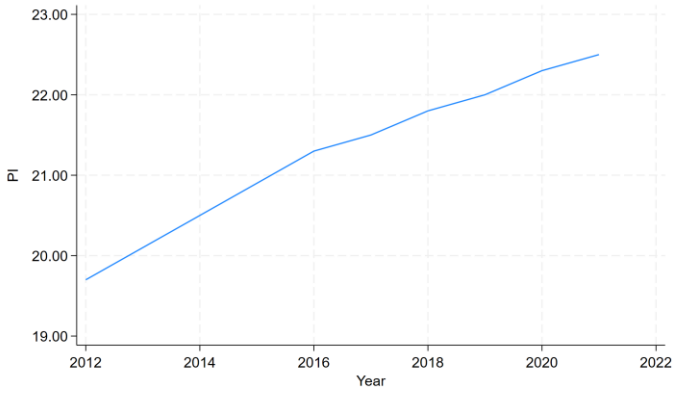
Source: Eurostat; Stata

Figure B.46 - Evolution of PI in France



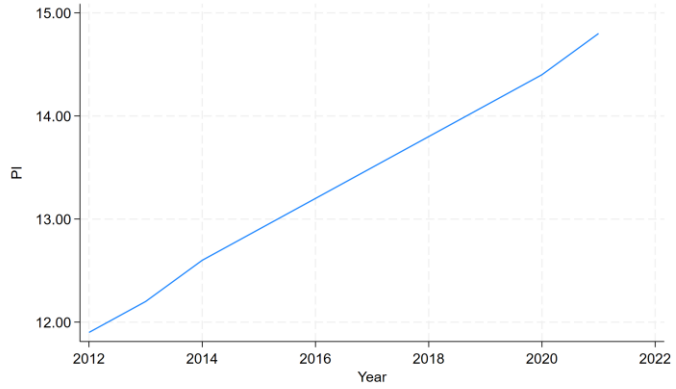
Source: Eurostat; Stata

Figure B.47 - Evolution of PI in Greece



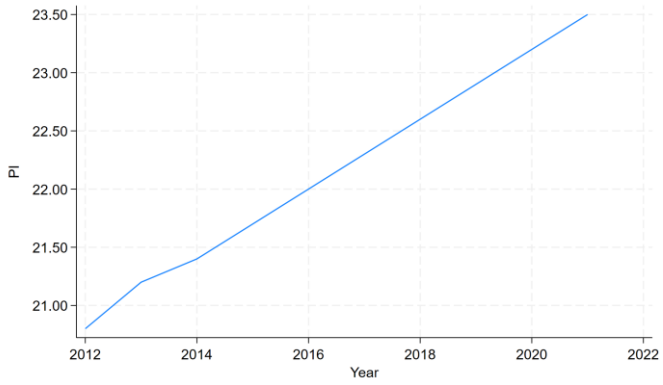
Source: Eurostat; Stata

Figure B.48 - Evolution of PI in Ireland



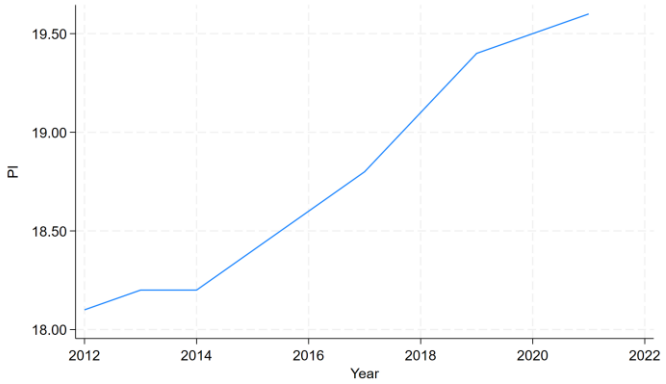
Source: Eurostat; Stata

Figure B.49 - Evolution of PI in Italy



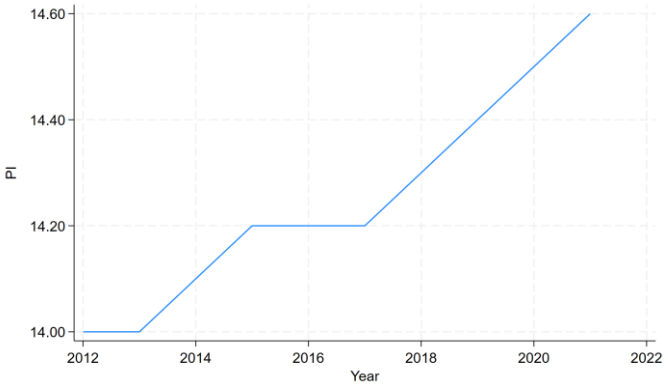
Source: Eurostat; Stata

Figure B.50 - Evolution of PI in Lithuania



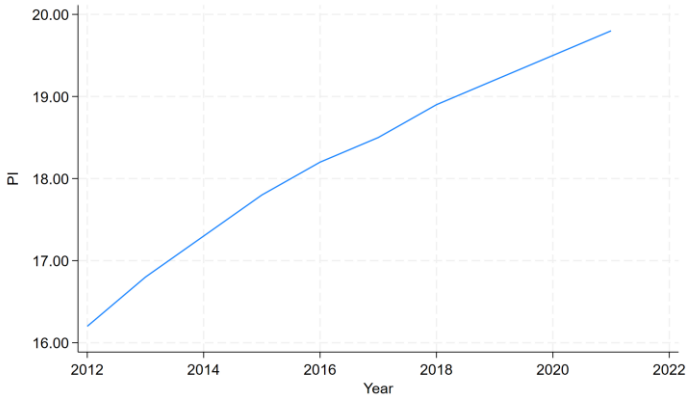
Source: Eurostat; Stata

Figure B.51 - Evolution of PI in Luxembourg



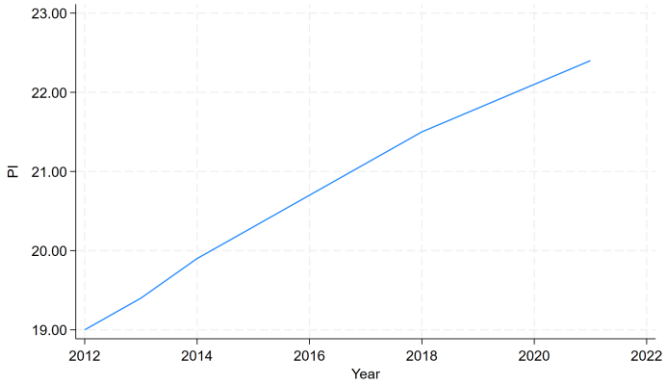
Source: Eurostat; Stata

Figure B.52 - Evolution of PI in The Netherlands



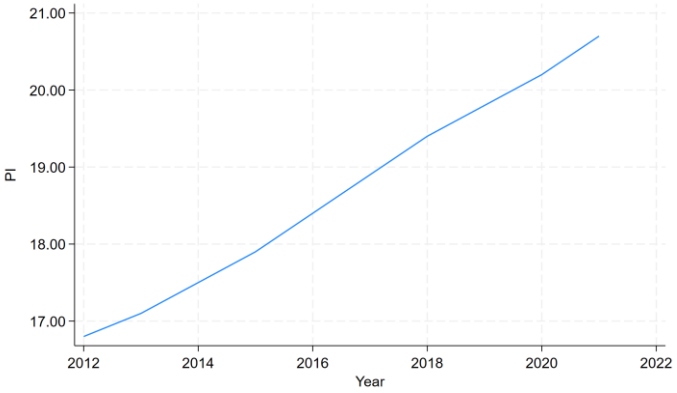
Source: Eurostat; Stata

Figure B.53 - Evolution of PI in Portugal



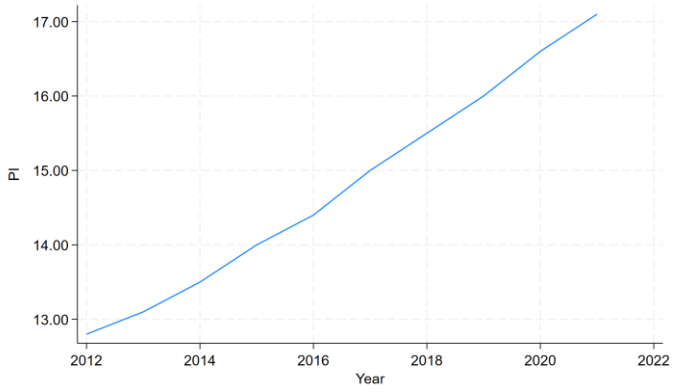
Source: Eurostat; Stata

Figure B.54 - Evolution of PI in Slovenia



Source: Eurostat; Stata

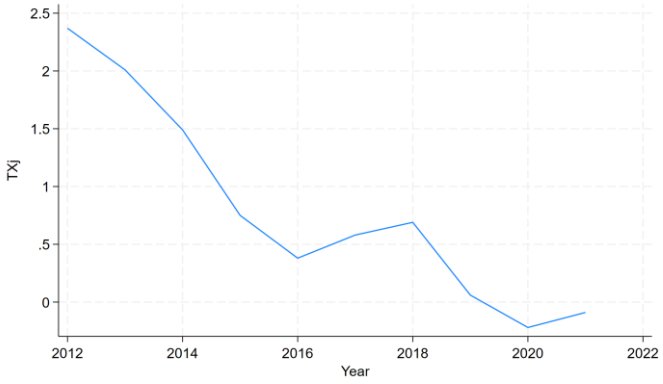
Figure B.55 - Evolution of PI in Slovakia



Source: Eurostat; Stata

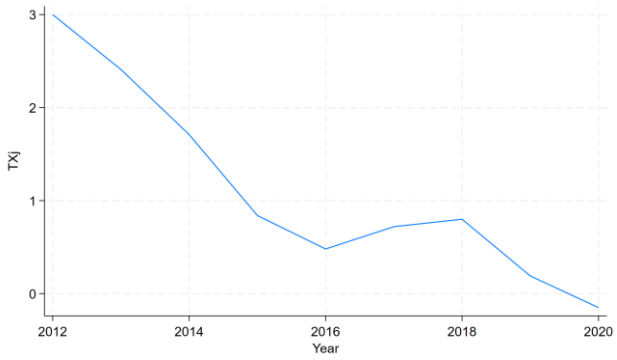
Annex B.4 - Evolution of TXj in each Eurozone country

Figure B.56 - Evolution of TXj in Austria



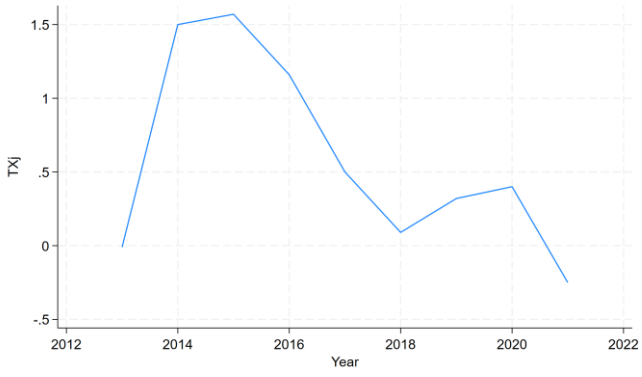
Source: Eurostat; Stata; OECD

Figure B.57 - Evolution of TXj in Belgium



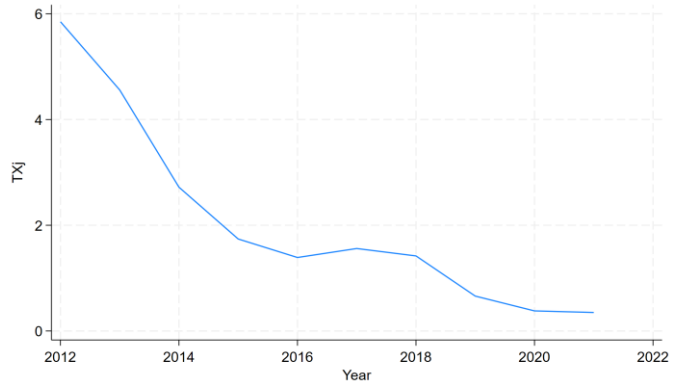
Source: Eurostat; Stata; OECD

Figure B.58 - Evolution of TXj in Germany



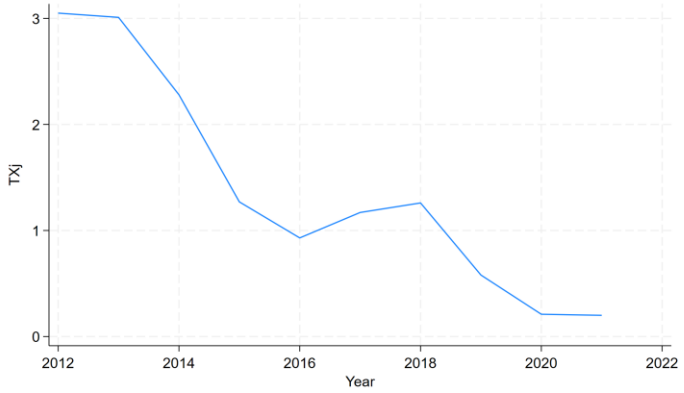
Source: Eurostat; Stata; OECD

Figure B.59 - Evolution of TXj in Spain



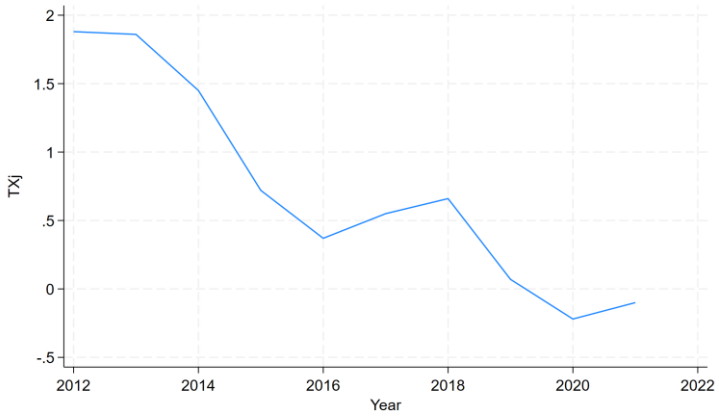
Source: Eurostat; Stata; OECD

Figure B.60 - Evolution of TXj in Eurozone



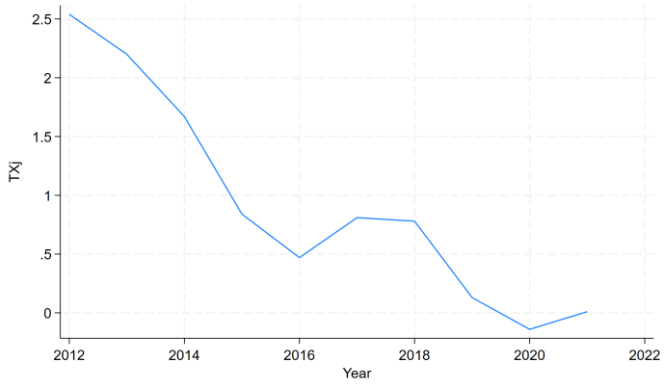
Source: Eurostat; Stata; OECD

Figure B.61 - Evolution of TXj in Finland



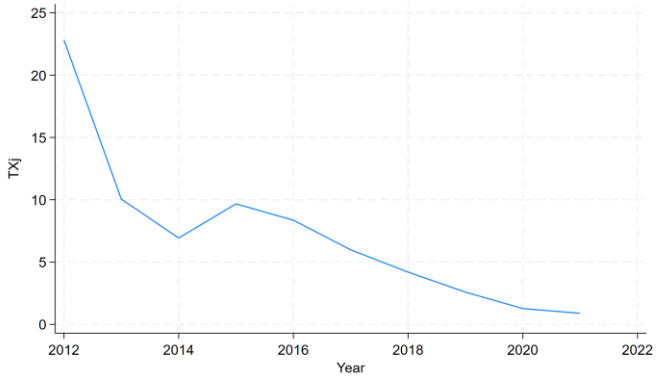
Source: Eurostat; Stata; OECD

Figure B.62 - Evolution of TXj in France



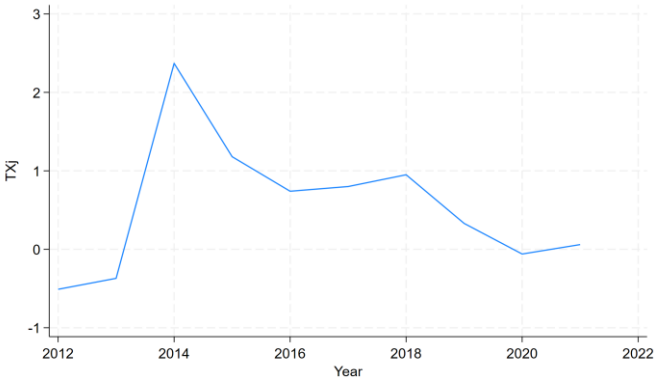
Source: Eurostat; Stata; OECD

Figure B.63 - Evolution of TXj in Greece



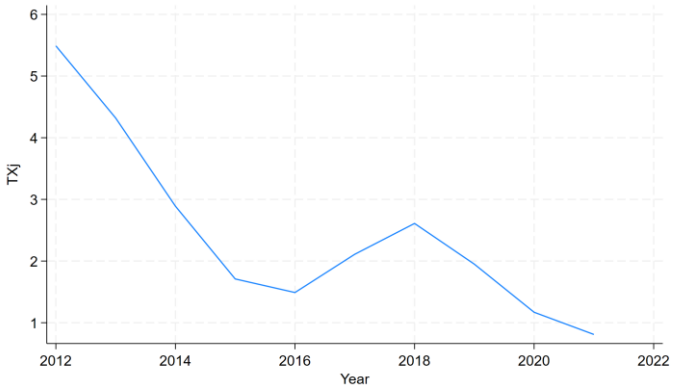
Source: Eurostat; Stata; OECD

Figure B.64 - Evolution of TXj in Ireland



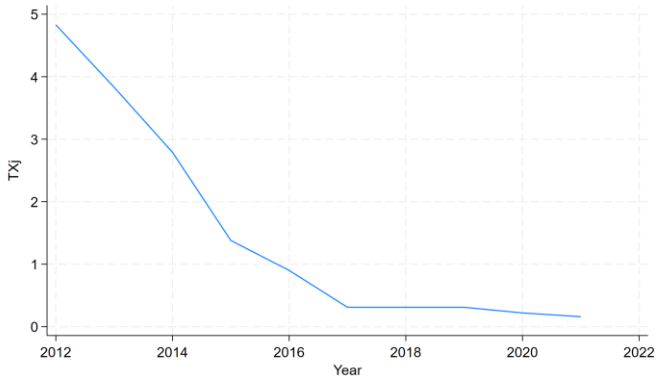
Source: Eurostat; Stata; OECD

Figure B.65 - Evolution of TXj in Italy



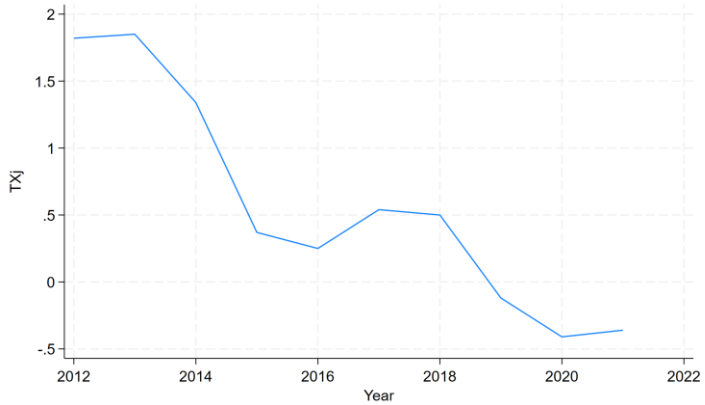
Source: Eurostat; Stata; OECD

Figure B.66 - Evolution of TXj in Lithuania



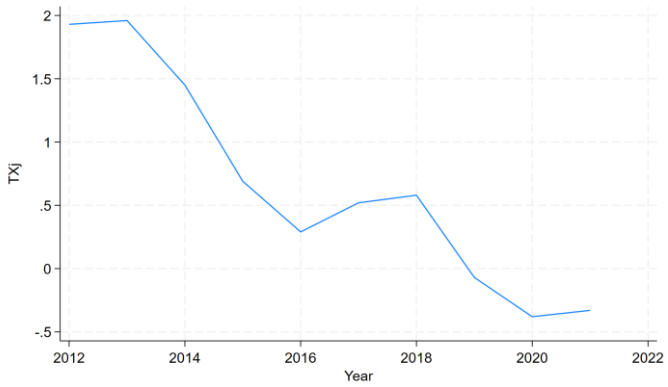
Source: Eurostat; Stata; OECD

Figure B.67 - Evolution of TXj in Luxembourg



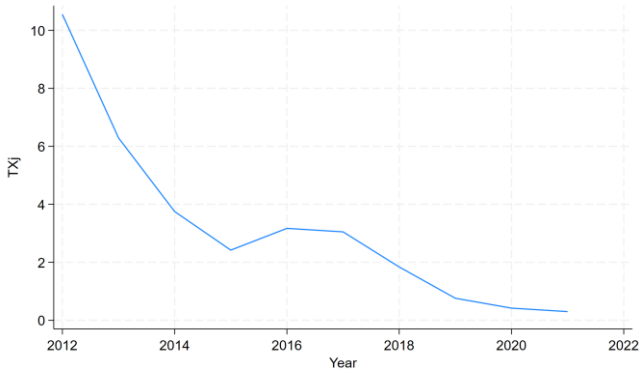
Source: Eurostat; Stata; OECD

Figure B.68 - Evolution of TXj in The Netherlands



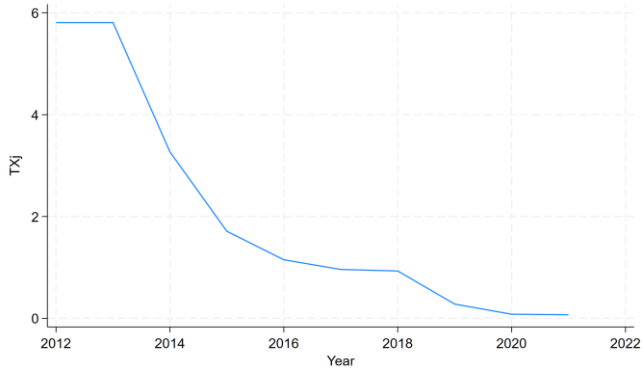
Source: Eurostat; Stata; OECD

Figure B.69 - Evolution of TXj in Portugal



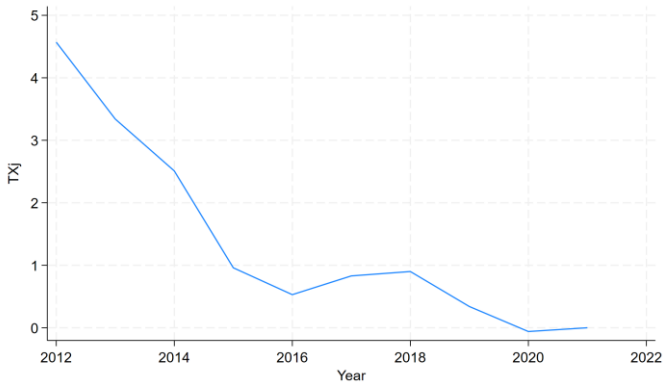
Source: Eurostat; Stata; OECD

Figure B.70 - Evolution of TXj in Slovenia



Source: Eurostat; Stata; OECD

Figure B.71 - Evolution of TXj in Slovakia



Source: Eurostat; Stata; OECD