

CAN EUROPEAN PENSION SYSTEMS SURVIVE DEMOGRAPHIC AGING? EVIDENCE FROM EU27 COUNTRIES

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Abstract: *The sustainability of public pension systems has become an increasingly important issue in the European Union due to demographic aging, declining fertility rates, and rising life expectancy. These demographic trends are gradually increasing the old-age dependency ratio, thereby placing growing financial pressure on pay-as-you-go pension systems that rely on contributions from the working population. This study examines whether public pension systems in the EU can remain financially sustainable under current demographic conditions. Using a quantitative and comparative research approach based on panel data for EU27 countries, the study analyses key demographic, economic, and institutional variables, including life expectancy, pension expenditure, replacement rates, and retirement age patterns. The analysis is supported by trend evaluation and cross-country comparisons, allowing for the identification of both temporal developments and structural differences between member states. The findings indicate a clear upward trend in the old-age dependency ratio, reflecting a growing imbalance between contributors and beneficiaries. Additionally, pension expenditure is rising in many countries, increasing fiscal pressure on public finances. The results also highlight a persistent gap between statutory and effective retirement ages, which further weakens system sustainability. Differences across country clusters reveal that while some systems struggle with financial sustainability, others face challenges related to adequacy and equity, particularly concerning the gender pension gap. The study concludes that there is no universal solution, and effective policy responses must balance sustainability, adequacy, and fairness. Ongoing reforms, including increasing retirement age, promoting labour market participation, and developing multi-pillar pension systems, are essential to ensure the long-term stability of pension systems in aging European societies.*

Keywords: *Pension Systems; Old-Age Dependency Ratio; Demographic Aging; Fiscal Sustainability*

JEL Classification: *H55; J11; J26*

1. Introduction

Pension systems play a central role in modern welfare states by providing income security for individuals after retirement and reducing poverty among older populations. The theoretical foundations of public pension systems can be traced back to Samuelson (1958), who introduced the concept of intergenerational transfers as a basis for Pay-As-You-Go pension schemes. In the European Union, public pension systems have long been one of the most important pillars of social protection. However, demographic and economic changes have raised increasing concerns about whether these systems can remain financially sustainable in the future.

One of the main challenges is demographic aging. Over the past decades, fertility rates have declined while life expectancy has increased significantly. As a result, the proportion of elderly people in the population is rising. This creates a growing imbalance between contributors and beneficiaries in pension systems. In many European countries, pension systems are based on the Pay-As-You-Go (PAYG) model, where current workers finance the pensions of current retirees. This system depends heavily on a stable ratio between the working population and retirees. Diamond (1965) developed the economic analysis of pension systems by examining their role within overlapping generations models and long-term economic equilibrium.

As the number of retirees increases and the working-age population shrinks, maintaining this balance becomes more difficult. At the same time, pension systems must continue to provide adequate income for retirees, creating a major policy challenge. Governments must find ways to ensure both financial sustainability and social protection.

This study aims to analyse the sustainability challenges facing public pension systems in the European Union and to evaluate how different countries are responding to these pressures. The main research question is whether pension systems can remain sustainable under current demographic trends. The study focuses on key demographic, economic, and institutional factors and examines how they influence pension system outcomes across EU member states.

2. Literature Review

Pension systems have been essential to contemporary welfare states. The explanation is straightforward: they help lower poverty among older populations when they are unable to work and offer income security to individuals who have stopped working. Public pension systems have a long history in Europe and are one of the most significant social protection pillars. The long-term viability of these systems has come under scrutiny amid significant demographic and economic transformations (Boado-Penas et al 2019, Havay 2025). Aging populations and shifting labour markets place mounting pressure on governments to reconcile the provision of adequate pension benefits with the imperative of fiscal sustainability.

A significant contribution to theoretical knowledge of the dynamics of the pension systems comes from Barr and Diamond (2006). In that research, they argued that pension systems have two important functions. First, they allow the individuals to streamline their consumption for the rest of their lives. Workers put money into pension systems during their working life and enjoy benefits from it after retirement. This helps them maintain financial stability and minimize uncertainty when they are

no longer part of the labour force. Second, pension systems play a very vital role in reducing poverty among older individuals in the society.

A well-designed pension system, according to Barr and Diamond (2008), must strike a balance between three important goals: sustainability, affordability, and adequacy. Making sure pension benefits give retirees a respectable standard of living is referred to as adequacy. The financial strain imposed on employees and the governments that fund the system is known as affordability. Conversely, sustainability is the capacity of pension systems to maintain long-term financial viability without unduly straining public coffers.

The aging of the population is one of the biggest problems facing pension systems today. While fertility rates have decreased over the past few decades, life expectancy has significantly increased in many European countries. Consequently, the percentage of the population that is older is increasing. Because retirees receive benefits for longer periods of time while the number of workers contributing to the system grows more slowly, this demographic shift has significant ramifications for pension systems.

As people get older, there's a big change in the number of workers compared to retirees, Börsch-Supan (2013). Previous studies have also shown the long-term financial effects of population aging. For example, Auerbach and Kotlikoff (1987) state that if structural reforms are not implemented, demographic shifts may drastically affect the ratio of contributions to benefits in public pension systems, raising economic pressure. Their research emphasizes how crucial forward-thinking policy design is to preserving long-term sustainability. One way to measure this is by looking at the old-age dependency ratio, which shows how many working-age people are there for every elderly person. When this ratio goes up, it means there are fewer workers to support a growing number of retirees, and that puts a lot of pressure on public pension systems. This can cause financial problems because there are not enough workers to cover the costs of supporting all the retirees.

Alternative pension plans have been suggested by a number of scholars and international organizations to address these issues. The significance of a multi-pillar pension system is emphasized by Holzmann and Hinz (2005). According to this framework, retirement income should come from a variety of sources, such as voluntary private savings, occupational pension plans, and public pensions. Countries can lower the risks of depending exclusively on public pension systems by diversifying their sources of retirement income.

The sustainability of pensions has also been extensively studied by international organizations. The OECD (Organisation for Economic Co-operation and Development) reports from 2023 and 2025 offer comparative evaluations of pension systems in various nations. According to these studies, many European nations have improved the sustainability of their pension systems in recent decades by implementing reforms. Rising retirement ages, pension reforms and private pensions are all contributing to significant changes in the global pension system (OECD 2023, 2025).

Similar long-term projections of public spending associated with population aging are provided by the European Commission in its report *The 2021 Ageing Report: Economic and Budgetary Projections for the EU Member States (2019–2070)* (European Commission, 2021). According to the report, pension spending is predicted to continue to be one of the biggest categories of EU government spending. Demographic trends suggest that pension systems will continue to face

major challenges in the upcoming decades, even though previous reforms have improved fiscal sustainability in some countries.

Furthermore, Feldstein (1974) contended that public pension plans might affect people's saving habits and economic capital accumulation. According to his analysis, pension system design has wider macroeconomic ramifications in addition to budgetary sustainability, which highlights the necessity of well-considered pension reforms.

Policy makers have proposed several policies regarding these increasing concerns. One of the most common reforms is increasing the retirement age. It means that people will be part of labour force for longer period. And it will also decrease the number of years during which retired people enjoy benefits. Encouraging private savings is also considered important reform. But according to Grech (2018), these reforms can backfire. He argues that these types of pension reforms often face resistance from the public because they involve unpopular measures. As a result, political feasibility and social factors play a key role in the success of pension reforms.

Additionally, empirical research reveals that while European nations experience comparable demographic pressures, the structure and design of their pension systems vary greatly. According to Peleckis, Peleckiene, and Peyravi's (2025) analysis of pension systems throughout Europe, most nations face similar issues with aging populations, rising pension costs, and shifting labor markets, despite differences in institutional arrangements.

Overall, the corpus of research suggests that ongoing policy adjustments and reforms will be required to maintain the sustainability of Europe's pension systems. As demographic aging continues to change European societies, governments will need to adjust pension systems to account for changing economic and demographic conditions while ensuring adequate income protection for retirees. Further research is still required to fully understand how policy decisions, demographic trends, and labor market developments interact to shape the future of pension systems in the European Union.

3. Methodology

This study employs a quantitative and comparative research methodology to analyze the sustainability challenges of pension systems throughout the European Union (EU27). The analysis is based on panel data, which combines both cross-country and time-series perspectives. This method is especially helpful for pension systems because demographic and economic changes happen slowly over time and are different in different countries. The study utilizes panel data to identify both structural disparities among countries and long-term trends, thereby offering a more comprehensive insight into the dynamics of pension systems.

The empirical analysis is based on two main sets of data. The first is a panel dataset that includes data from multiple years for EU27 countries. It has important numbers like the old-age dependency ratio, pension spending as a percentage of GDP, life expectancy for men and women, healthy life years at age 65, the legal and actual retirement ages, and the total replacement rates. You can look at trends over time with this dataset, and it helps you see how demographic and pension-related indicators change from one country to the next. The second dataset has more cross-sectional data, like GDP per capita in purchasing power standards (PPS), country

clusters (like Continental, Southern, and Central and Eastern Europe), gender pension gaps, and other pension indicators. The combination of these datasets ensures both depth and comparability, making it possible to conduct a detailed and consistent analysis.

The variables chosen for this analysis are drawn from existing research on pension systems and what makes them financially viable over time. Among the most telling indicators are demographic ones especially the old-age dependency ratio and life expectancy. The old-age dependency ratio matters because it captures the balance between the elderly population and those still in the workforce. As this ratio climbs, a shrinking pool of workers is left to bear the financial weight of an expanding retired population which puts pressure on pay-as-you-go pension models very hard. Meanwhile, life expectancy and healthy life years shed light on how long retirees are likely to draw from pension funds and the general quality of aging across a population (See Table 1 for a list of all variables included in the analysis).

Economic variables are included to show the financial side of pension sustainability. GDP per capita is a measure of how well the economy is doing and how much money the government has. The percentage of GDP that goes to pensions shows how much pensions cost the government. In societies that are getting older, higher levels of pension spending may be a sign of increasing fiscal pressure. Institutional variables are also used to look at how well a policy is designed and how well a system works. These are the legal retirement age, the age at which someone can leave the workforce, the overall replacement rates, and the gender pension gap. These variables enable an evaluation of sustainability, adequacy, and equity within pension systems.

The analytical framework is divided into three main parts. The first step is descriptive analysis, which means summarizing and comparing key indicators across countries. This step helps in finding commonalities and differences in the features of pension systems, which can then be used as a starting point for more research. It also shows how different regions and levels of economic development are, which is important for understanding the EU's structural diversity.

The second stage shifts the focus to trend analysis, drawing on the panel dataset to track how key indicators have moved over time. Central to this stage is the old-age dependency ratio, which serves as the primary lens through which demographic pressure is examined, with findings pointing to a consistent upward trajectory across EU27 countries — meaning that elderly individuals are making up an ever-larger share of the population relative to those of working age, a trend that lies at the heart of the growing strain on pension systems.

Beyond demographics, the analysis also traces developments in pension spending and retirement patterns, where rising expenditure signals intensifying fiscal pressure on public finances, while the gap between the legally mandated retirement age and the age at which people actually leave the workforce offers a window into labor market dynamics and how effective — or ineffective — policy interventions have been in practice.

There are a lot of benefits to using panel data. It helps the study see how things change over time, adds more observations, and makes the analysis more reliable. It also lets you make meaningful comparisons between countries, which is important for understanding pension systems in the EU. Also, the chosen variables are closely related to important policy issues like the aging population, participation in the labor market, and fiscal sustainability.

It's important to keep in mind, though, that there are some limits. The study utilizes secondary data, which may contain absent values or discrepancies. Also, the analysis finds trends and connections between variables, but it doesn't show strict cause-and-effect relationships. Pension systems are complicated and affected by many things, such as political and institutional dynamics that may not be fully reflected in quantitative data. Even with these problems, the method gives a strong and dependable way to look at problems with pension systems.

In general, this method lets us look at the long-term viability of the EU's pension system in a thorough way. The study incorporates demographic, economic, and institutional variables, thereby explaining the complexity of pension systems and offering significant insights into the challenges they encounter. The results help us understand how European countries can change their pension systems to keep up with changes in the economy and population.

Table 1. Summary of Variables: Definitions, Classifications, and Expected Relationships with Pension System

Old-Age Dependency Ratio (%)	Number of persons aged 65 and over per 100 persons of working age (15–64). Reflects the demographic burden on the active population.	Demographic	Negative: A higher ratio increases fiscal pressure on pay-as-you-go pension systems by reducing the number of contributors per beneficiary.
Life Expectancy at Birth (years)	Average number of years a newborn is expected to live under current mortality conditions. Reported separately for males and females.	Demographic	Negative: Longer life expectancy extends the duration of pension payments, increasing long-term fiscal costs.
Healthy Life Years at Age 65	Average number of years a person aged 65 is expected to live in a healthy condition, by gender.	Demographic	Positive: More healthy years at older ages support extended labor market participation, increasing contributions and reducing early benefit claims.
Pension Expenditure (% of GDP)	Total public pension spending expressed as a percentage of gross domestic product. Captures the fiscal weight of pension obligations.	Economic	Negative: Higher expenditure relative to GDP indicates greater fiscal strain and reduced long-term sustainability.
GDP per Capita (PPS)	Gross domestic product per capita expressed in purchasing power standards (EU27 = 100). Measures relative economic development.	Economic	Positive: Higher GDP per capita reflects greater fiscal capacity to fund pension liabilities.
Aggregate Replacement Rate	Ratio of median pension income (ages 65–74) to median labor income (ages 50–59).	Institutional	Negative: Higher replacement rates increase pension expenditure and

	Measures the income replacement provided by pensions.		place greater pressure on public finances, undermining long-term fiscal sustainability.
Gender Pension Gap (%)	Percentage difference between average pension income received by men and women. Reflects accumulated labor market inequalities.	Institutional	Negative for equity: A larger gap signals inadequate coverage for women and systemic inefficiencies in pension design.
Statutory Retirement Age (years)	The legally defined age at which individuals become entitled to full pension benefits. Reported separately for men and women.	Institutional	Positive: A higher statutory age reduces benefit duration and extends the contribution period, improving fiscal sustainability.
Effective Exit Age (years)	Average age at which individuals actually withdraw from the labor market, by gender. Derived from labor force survey data.	Institutional	Positive: A higher effective exit age reduces the gap with statutory age, increasing contribution revenues and reducing benefit duration.
Retirement Age Gap (years)	Difference between the statutory retirement age and the effective labor market exit age, by gender.	Institutional	Negative: A larger gap indicates premature labor market exit, reducing contributions and extending pension payment periods.

Source. Own creation

4. Results and Findings

This part shows the main results of the empirical study of pension system indicators in the European Union (EU27). The findings are derived from descriptive statistics, trend analysis, and a comparative evaluation of essential demographic, economic, and institutional variables. The goal is to find the main patterns that affect the long-term health of pension systems and to point out differences between countries.

One of the most significant findings to emerge from the analysis is the steady rise in the old-age dependency ratio across all EU27 countries.

Figure 1 clearly shows a consistent upward trend in the old-age dependency ratio across EU27 countries, confirming the growing imbalance between the working-age population and retirees. Trend analysis makes it evident that the balance between older individuals and those of working age has been shifting persistently in one direction, driven by broader demographic forces reshaping Europe — namely, declining birth rates and people living considerably longer than previous generations.

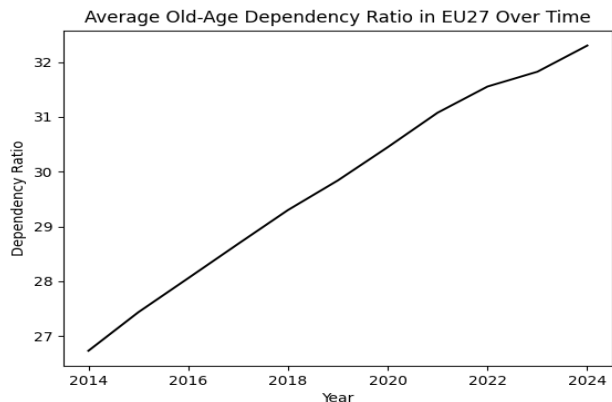


Figure 1. Average old-age dependency ratio in the EU27 over time
Source of data: Eurostat: SDG_08_10, Eurostat: DEMO_PJAN_ORD, OECD: Pensions at a Glance

The implications for pension systems are substantial, particularly for those operating under the pay-as-you-go model, where the financial contributions of today’s workers directly fund the benefits of today’s retirees. As the retired population grows at a faster pace than the workforce, sustaining existing pension arrangements becomes increasingly difficult. This finding lends strong support to the argument that population aging stands as one of the principal forces behind the mounting pressure.

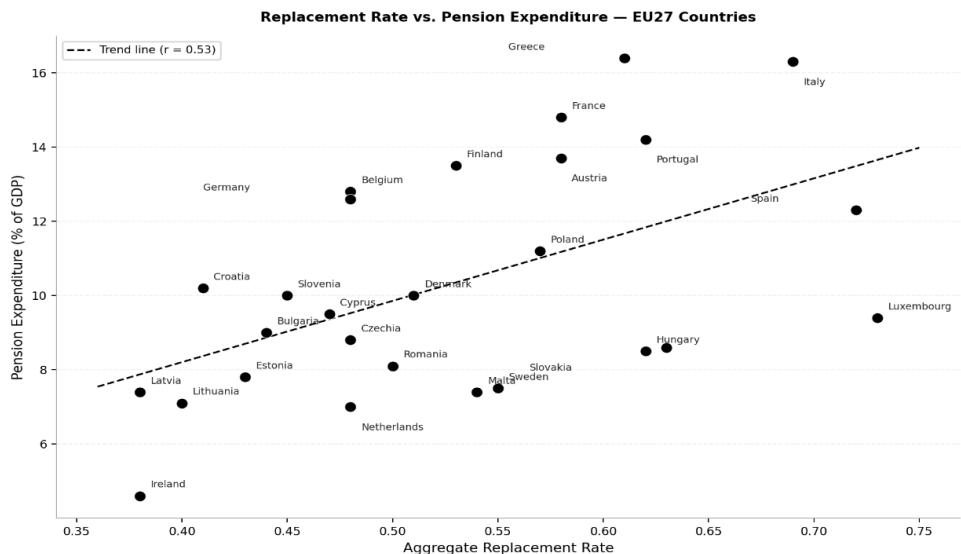


Figure 2. Replacement rate vs. Pension expenditure – EU27 countries
Sources: Source of data: Eurostat: SDG_08_10, Eurostat: DEMO_PJAN_ORD, OECD: Pensions at a Glance (2025)

In addition to the demographic pressures already mentioned, the analysis shows that pension spending as a share of GDP is clearly rising in a number of EU countries. The overall trend is clear: governments are under more financial strain than ever before, even though the actual levels vary from country to country. Countries that have better pension systems with higher replacement rates tend to spend more of their economic output on pensions (see Figure 2.). This makes it hard to keep benefits adequate and the system financially stable at the same time. More generous pension benefits give retirees more income security, but they also put more strain on public finances in the long run. This tension is particularly evident in countries with ageing populations and relatively early retirement patterns.

The connection between the legal retirement age and the real retirement age gives us more information about how the pension system works. The analysis indicates that in numerous EU nations, the effective retirement age is still lower than the legal retirement age (see Figure 3.). This means that people tend to leave the workforce earlier than the law says they have to, often through early retirement plans or other means.

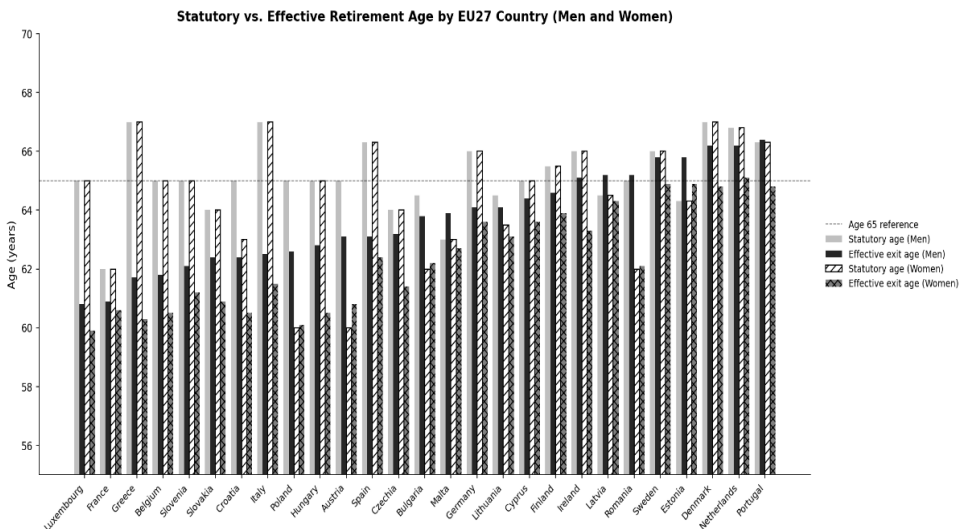


Figure 3. Statutory vs. Effective retirement age by EU27 countries (man and women)
Source of data: Eurostat: SDG_08_10, Eurostat: DEMO_PJAN_ORD, OECD: Pensions at a Glance (2025)

This gap puts more strain on pension systems because it lowers the number of people who pay into them and lengthens the time that people get benefits. Countries that have put policies in place to make the effective retirement age closer to the legal retirement age tend to have better long-term sustainability results.

Another significant discovery pertains to the disparities in replacement rates among nations. The overall replacement rate, which compares pension income to earnings before retirement, is very different in each EU member state. Countries with higher replacement rates give retirees better pension benefits, which helps them have enough money to live on. But these systems often come with higher costs for pensions and more pressure on the budget. Countries with lower replacement rates,

on the other hand, may be able to keep their finances stable better, but they may have problems with pension adequacy and the risk of poverty in old age. This shows a basic policy trade-off between making sure retirees have enough money to live on and keeping the economy stable.

The comparative analysis of country clusters shows that there are clear patterns in how pension systems are set up and how they work in different parts of the world. Most countries in continental Europe have higher replacement rates and pension systems that are fairly generous. As their populations get older, these countries are under more and more financial strain because they rely so much on public pension plans. Some of the highest levels of pension spending as a percentage of GDP are in southern European countries like Italy and Spain. These systems are very sensitive to changes in the population, and they often need to be reformed all the time to stay stable.

On the other hand, countries in Central and Eastern Europe usually spend less on pensions and have lower replacement rates. This may seem like a good idea from a financial point of view in the short term, but it does raise real worries about whether retirees in these countries are getting enough money to live on and whether the gap between older people will get worse over time. So, the problem for these countries is not just how to cut costs, but how to build pension systems that are strong enough to give people real protection without going broke.

The analysis also shows how economic factors affect the results of pension systems. Countries with higher GDP per capita usually have more money to spend on pensions. But just because an economy is more developed doesn't mean it will always be able to keep going. In some cases, richer countries also have better pension systems, which can make it harder to keep spending in the long term. This means that both the economy and the way policies are set up are important for how well the pension system works.

Another important finding is that there is gender inequality in pension outcomes. The gender pension gap is still very large in many EU countries. This is because men and women have different patterns of working, earning money, and advancing in their careers. Women are more likely to have careers that are cut short and make less money over their lives, which means they get less money in retirement. This shows how important it is to think about fairness, along with sustainability and adequacy, when making pension policy.

Figure 4 illustrates the gender pension gap across all EU27 member states in 2023, highlighting the considerable variation between countries. As shown in Figure 3, the gap ranges from just 1.8% in Estonia to 41.2% in Luxembourg, with an EU27 average of 23.5%, confirming that unequal pension outcomes between men and women remain a structural challenge across the European Union.

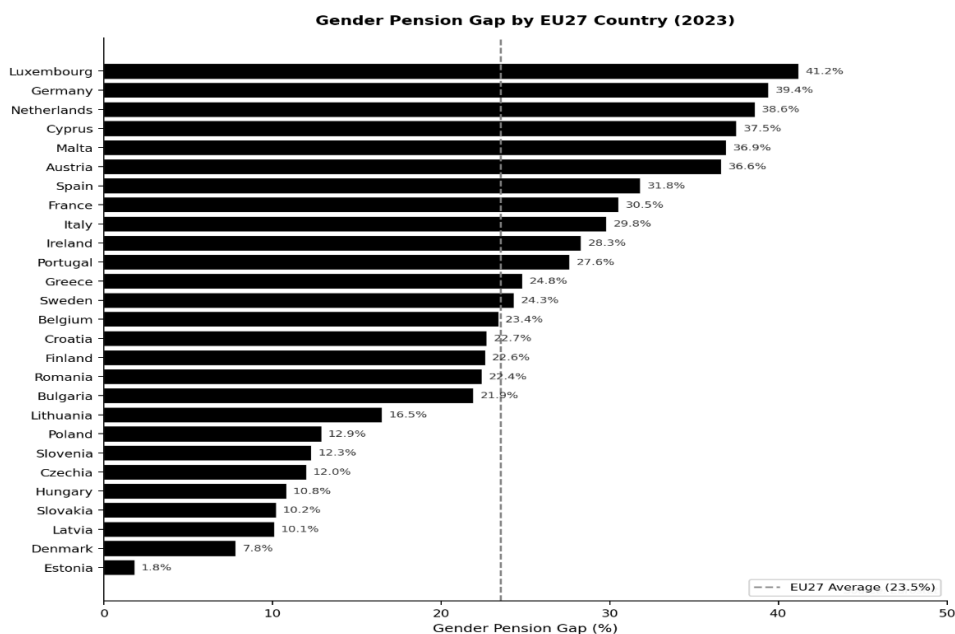


Figure 4. Gender pension gap by EU27 countries (2023)

Source of data: Eurostat: SDG_08_10, Eurostat: DEMO_PJAN_ORD, OECD: Pensions at a Glance (2025)

The analysis also shows that pension reforms are becoming increasingly important across the European Union. Many countries have introduced measures such as raising the statutory retirement age to extend working lives and reduce the duration of benefit payments. Pension formulas have also been adjusted in several cases by linking benefits more closely to lifetime contributions or life expectancy. In addition, the gradual development of multi-pillar pension systems has reduced reliance on public schemes by promoting occupational and private savings. Policies encouraging higher labour market participation, particularly among older workers and women, have further supported sustainability. While these reforms have contributed to improving long-term stability, their effects are often gradual, vary across countries, and remain influenced by economic conditions and political constraints.

5. Conclusions

Overall, the results clearly show that European pension systems are facing a complicated set of problems caused by an aging population, economic pressures, and the way institutions are set up. Concerns about sustainability are growing because of the rising old-age dependency ratio, rising pension costs, and patterns of early retirement. At the same time, the differences in replacement rates, economic capacity, and policy frameworks show how different pension systems are in the EU. What these findings ultimately point to is that there is no one-size-fits-all answer to the pressures bearing down on pension systems across Europe. Any meaningful policy response must strike a balance between keeping systems financially viable,

ensuring retirees can live with dignity, and treating different groups fairly — all while accounting for the fact that each country comes to this challenge with its own economic realities, demographic trajectory, and institutional history. What works well in one context may be entirely unsuitable in another. If anything, the results make a compelling case for ongoing reform and fresh thinking in policy design, so that pension systems can hold up over the long run without leaving aging populations without the support they need.

This study aimed to analyze the sustainability challenges confronting pension systems within the European Union and to evaluate the responses of various countries to these pressures. The results clearly show that European pension systems are under a lot of stress, mostly because of long-term changes in the population. The old-age dependency ratio is going up because life expectancy is going up and fertility rates are going down. This directly affects the balance between contributors and beneficiaries. This change is at the heart of the sustainability problem, especially for countries that depend on pay-as-you-go pension systems.

The results also show that pension spending is going up in many EU countries, which is putting more strain on public finances. Higher spending can mean better social safety nets and bigger pension benefits, but it can also make people worry about the long-term health of the economy. This presents a core policy challenge: guaranteeing sufficient income for retirees while preserving a financially viable system. The difference in replacement rates between countries shows this trade-off even more clearly. Systems that do well in terms of adequacy often have more financial problems.

An additional primary conclusion relates to the way people approach retirement. The persistently large gap between statutory and effective retirement ages has ongoing consequences across countries. The more people leave the labor market before they reach the statutory retirement age reduces contributions to the pension system while extending benefit payouts, creating further stress on pension systems financially. Therefore, addressing the gap between statutory and actual retirement ages will aid sustainability. Furthermore, measures encouraging longer working lives (such as increasing the statutory retirement age or promoting active aging) can play a major role in pension reform going forward.

The findings of the study further show that there is no one size that fits all in Europe regarding challenges related to their respective pension systems. While some EU countries face hurdles related to ensuring sustainable pensions (due to high costs and older populations), others have concerns related to equity and adequacy. The continued existence of the Gender Pension Gap shows that structural inequalities which exist in pension systems must be addressed. Therefore, reforms in the pension system should evaluate financial sustainability as well as equitable outcomes.

The analysis has found a larger trend: pension systems are slowly moving toward having more than one pillar. Countries want to diversify their sources of retirement income and rely less on public finances by combining public, occupational, and private components. This method could be helpful, but it also brings up new problems and risks, such as unequal access to private pensions and being affected by changes in the financial markets.

The results of this research show that there is no universal answer to the many problems facing pension systems in Europe. The most effective way to achieve this goal through reform will be through a balanced approach that also considers

adequacy and sustainability. Future policy solutions must be developed around how to align pension systems with demographic trends, improve participation in the labor market, and provide equal and equitable results for everyone, regardless of their demographic.

In conclusion, the sustainability of European pension systems will rely heavily on how quickly and effectively governments implement good reforms. As demographics change, policy responses to these issues will increasingly need to be coordinated and to anticipate future developments. This study seeks to support the overall understanding of these issues and to encourage ongoing adaptation of pension systems, in order to guarantee the future of these systems, given that European societies are producing an ever-increasing number of older people.

There are several limitations to this research that should be noted. Due to the descriptive and comparative character of the methodology, the research does not establish causal effects even when it finds significant trends and correlations between crucial variables. It is more difficult to capture long-term interactions and adjustment processes inside pension systems when dynamic regression approaches are lacking. Furthermore, the quantitative methodology does not adequately account for institutional and political issues that affect pension results. Future studies could overcome these constraints by using more sophisticated econometric techniques, including dynamic panel regression models, to gain a deeper comprehension of long-term dynamics and causal linkages. To gain a fuller understanding of the efficacy of policies and the structural variations among European pension systems, future research may also include country-specific analysis.

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