

A Work Project, presented as part of the requirements for the Award of a Master's degree in
Economics from the Nova School of Business and Economics.

Sustainability of the Italian Pension System: A Forecasting Approach to Policy and
Demographic Challenges

Samuele Siano

Work project carried out under the supervision of:

Paulo M. M. Rodrigues

17-12-2024

Abstract

This work project analyzes the sustainability of the Italian pension system, which is increasingly threatened by demographic and economic changes. With an aging population and declining birth rates, the system risks collapse. The objective is to evaluate strategies to balance financial sustainability and intergenerational equity. A VAR model is employed to study the relationships between population, birth rates, and life expectancy using a multitemporal approach, analyzing data from different historical periods to assess the effects of past reforms. Exogenous shock scenarios are simulated using the LP model to evaluate the potential impact of migration flows and increased birth rates. The research offers recommendations to maintain pension sustainability while safeguarding social justice and economic stability.

Keywords: Pension System, Sustainability, Demographic Trends, Intergeneration Equality, Policy Reform, Vector Autoregressive Model (VAR), Forecasting and Local Projection (LP)

This work used infrastructure and resources funded by Fundação para a Ciência e Tecnologia (UID/ECO/00124/2013, UID/ECO/00124/2019 and Social Sciences DataLab, Project 22209), POR Lisboa (LISBOA-01-0145-FEDER-007722 and Social Sciences DataLab, Project 22209) and POR Norte (Social Sciences DataLab, Project 22209).

Table of Contents

Introduction	3
Literature Review	5
The Italian Pension System (IPS)	5
Related Studies	11
Methodology	14
Data Collection	15
Model Implementation	15
Estimation	16
Impulse Response Function (IRF)	18
Results and Discussion with Related Studies	20
Conclusion	22
Reference	24
Appendix	28

Introduction

The Italian pension system operates on an intergenerational pact, where current pensioners receive their pensions from contributions made by active workers. This mechanism relies on mutual trust and the shared expectation of equitable functioning across generations. However, persistent demographic and economic pressures threaten this delicate balance, highlighting the urgency of finding sustainable solutions.

The Italian system adopts a pay-as-you-go model, where pensions are financed directly by the contributions of active workers. This contrasts with the capitalization model, in which contributions are invested over time and paid out as pensions upon retirement. However, in Italy, a rapidly aging population, declining birth rates, and reduced migration flows pose significant challenges to the sustainability of this system. Over the past 50 years, profound demographic shifts have already heavily impacted the social security system, with repercussions expected to intensify in the coming decades.

Currently, the Italian pension system is at the center of a heated debate over its long-term sustainability. Key factors include an aging population, a steadily declining birth rate, and reduced net migration flows. These elements have directly led to a shrinking workforce and an increase in the number of pensioners, exacerbating the financial strain on state resources.

According to the 2024 Ageing Report, the Italian population will continue to age rapidly in the coming decades. The ratio of workers to pensioners, currently 3.3 to 1, is projected to drop to just 1.9 to 1 by 2070, posing a severe threat to the pay-as-you-go system. Unlike a funded system, the pay-as-you-go model is particularly vulnerable to such demographic changes. Addressing these issues requires not only technical adjustments but also a broader understanding of the social and economic dynamics shaping intergenerational equity.

Since the 1990s, Italy, like other European nations, has introduced a series of pension reforms. Among the most significant was the transition from a wage-based to a contribution-based system, where pensions are calculated based on lifetime contributions rather than recent earnings. While these measures improved short-term sustainability, they may prove insufficient for addressing long-term challenges. Population aging affects not only the pension system but also the broader economy. On the one hand, a shrinking labor force reduces the contribution base needed to fund pensions; on the other hand, an aging workforce can dampen productivity, undermining economic competitiveness of the Italian economy and creating a vicious cycle of stagnation and fiscal strain.

According to the Fiscal Sustainability Report 2018, pensions account for 16.4% of Italy's GDP, one of the highest shares in Europe, and are projected to remain at this level for decades. Without further action, this will likely worsen the country's economic imbalance. Moreover, intergenerational equity is a growing concern. Younger generations face higher contributions and lower pension prospects, risking social tensions and eroding trust in the system. Balancing the needs of older cohorts, who often require flexibility in retirement policies, with the demands of younger generations seeking future security, presents a complex policy challenge.

This work project investigates the sustainability of the Italian pension system, focusing on the interplay between demographic trends and past reforms. Specifically, it evaluates the effectiveness of these reforms and examines the role of demographic variables through forecasting approach across historical periods. A Vector Autoregressive (VAR) model is employed to capture dynamic relationships between key variables, such as population, birth rate, life expectancy, and pensioner numbers. This method provides a comprehensive view of how these factors interact over time. Beginning in 2025, exogenous shock scenarios will be introduced using the Local Projection (LP) model to simulate the impacts of unforeseen events, such as increased migration or a sudden rise in the birth rates, on system sustainability. These

models not only assess immediate impacts but also offer insights into the long-term implications of alternative policy scenarios.

In conclusion, this research seeks to identify long-term solutions to ensure the sustainability of the Italian pension system without compromising intergenerational equity or fiscal stability. By providing evidence-based policy recommendations grounded in robust economic and demographic analysis, the work project aims to contribute to the public debate and support future welfare reforms. By addressing both the technical and social dimensions of the pension crisis, this research highlights actionable strategies to achieve economic viability while promoting social justice.

Literature Review

The Italian Pension System (IPS)

- *The Evolution of the IPS*

In this section I will examine key studies and reports relevant to my research on the Italian pension system, aiming to deepen the understanding of current challenges and future perspectives. Among these, the Ageing Report 2024 serves as a primary source, providing a comprehensive overview of the sustainability of the Italian pension system within a context marked by profound and ongoing demographic and economic changes.

The report begins by emphasizing the significance of the 1995 "Dini" law, which introduced the Notional Defined Contribution (NDC) system. This reform made the pension system more uniform and flexible, with a gradual transition from the Defined Benefit (DB) to the NDC system. It also implemented automatic adjustment mechanisms, enabling pension parameters to adapt to changes in life expectancy and inflation. These measures have been pivotal in maintaining the system's sustainability in an ever-evolving environment (European Commission, 2016).

Under the NDC system, pensions are calculated as the product of two main elements: total contributions paid during working life capitalized based on GDP growth (calculated as a five-year moving average), and a transformation coefficient. The latter considers factors such as life expectancy, mortality probability, and the possibility of leaving a surviving spouse. This approach results in a pension proportional to the contribution rate and directly linked to both the contribution period and retirement age.

In contrast, the previous DB system calculated pensions as a percentage of the final salary, typically considering only the last year of employment. This approach guaranteed a replacement rate of 70-80%, which placed a significantly higher financial burden on the government compared to the NDC system. Additionally, the system favored collusive mechanisms, allowing for an artificial increase of the salary in the last year of work to obtain a higher pension allowance than would have been received considering the average real wage (Rivista Italiana di Public Management, 2021).

Currently, the Italian pension system offers two types of retirement: old-age retirement, which requires reaching the Statutory Retirement Age (SRA) and at least 20 years of contributions, and early retirement, which allows individuals to retire at a younger age but involves a significant reduction in the pension allowance. In 2018, the legislation standardized the SRA for both men and women at 66 years and 7 months, a change made possible by the mechanisms introduced in 2012 under the "Fornero" law to gradually raise the retirement age for women (European Commission, 2018).

The subsequent adjustments were determined by the automatic adjustment mechanisms of the retirement age in relation to life expectancy, applied every two years. The last of these adjustments took place in 2019, bringing the retirement age to 67 with an increase of 5 months; thereafter, no further increases were expected due to the reduction in life expectancy linked to

the Covid-19 pandemic. The report does, however, highlight that in addition to the general increase in retirement age, there is a significant exception for a particular group of workers, the so-called "draining" jobs. This category includes those who perform tasks with high intensity of physical effort, exposing them to a more rapid deterioration of their health. For these workers, there is no adjustment of the retirement age based on life expectancy, and the retirement requirement varies between 61 and 64 years with a minimum of 35 years' contribution (Garibaldi and Boeri, 2016).

After this overview of the pension system, which is necessary to frame my study, the report focuses on a comparative analysis of Eurostat's demographic forecasts made in 2019 and 2022. The comparison of demographic forecasts is a crucial step in our analysis, as it allows us to understand how the sustainability of the pension system has evolved over the two periods.

- *Demographic Dynamics*

It is noted that for the same forecast period 2022-2070, the 2022 estimates predict a 9.7% population decline - one percentage point less than projected in the 2019 forecasts. This revision is attributed to an increase in the expected migration flows, despite a decrease in fertility rates. Specifically, the Total Fertility Rate (TFR) was significantly revised downward between the two projections, from 1.34 in 2019 to 1.24 in 2022. Although the TFR is expected to rise gradually until 2070, the revised growth is lower than previously forecasted, with estimates adjusted from 1.52 to 1.45 by 2070. Conversely, the expected migratory flows have been revised upwards, increasing from 216,000 to 250,000 annually for the period 2023-2070.

As regards life expectancy, similar growth rates are observed in the two forecasts, with a slight increase in 2022: an increase of 6 years for men and 5.5 years for women. This increase, slightly higher than previous projections, reflects the lower levels of the base year negatively affected by the Covid-19 pandemic, which has had an impact on the temporary reduction in life expectancy.

The factors described, together with the gradual retirement of the baby-boomers generation, contribute to population reduction. An indicator of this trend is the old-dependency ratio (calculated as the ratio between pensioners and the working population), which rises from 40.8% in 2022 to a peak of 66% in 2050, then decreases slightly to 65.5% by 2070. This trend signals a significant impact on pension and other welfare expenditures.

In the labor market, the workforce is projected to decline by 8.3% over the period 2022-2070, a smaller decrease compared to the 11.6% decline forecasted in 2019. In both projections, this decrease is due to an increase in the retired population, which proportionately decreases the active labor force. However, the activity rate for the 20-64 age group increases from 60.3% in 2022 to 67.4% in 2070, an increase of one percentage point over previous estimates. This increase is attributable to the increased participation in work of older individuals, influenced by higher retirement requirements introduced by automatic adjustment mechanisms. This trend is further supported by projections on the average labor market exit age, which is estimated to reach approximately 70 years and 2 months by 2070, reflecting increased life expectancy.

- *Pension Expenditure*

The last component analyzed in the report is pension expenditure as a proportion of GDP, which reaches its peak at 17.6% in 2036, then falls to 15.5% in 2050, converges to 13.7% in 2060 and stabilizes on these values until 2070. This indicator is crucial to assess the sustainability of the pension system: on the one hand, the initial increase in expenditure is attributable to the transition of the baby-boomers generation from the workforce to retirement and the introduction of rules such as "Quota 100," that has facilitated early retirement. During this phase, the adjustment mechanisms are not able to fully offset the increase in expenditure. On the other hand, from 2036 onwards there is a progressive decrease in expenditure as a proportion of GDP due to the completion of the transition to the NDC system and the reduction of the dependency

ratio. The latter is explained by the increase in retirement age requirements, which slow down the exit from the labor market of the baby-boomers generation (European Commission, 2018).

In order to carry out the most detailed analysis possible, it is useful to observe the breakdown of public expenditure on pensions as a proportion of GDP, expressed by the following formula:

$$\frac{Pension\ Exp.}{GDP} = DR \times CR \times BR \times \frac{Pop.\ 20 - 64}{Hours\ Worked}$$

This breakdown allows us to identify how the demographic transition of the baby boomers' generation negatively affects the state budget, in particular through the Dependency Ratio (DR

$= \frac{Pop.65+}{Pop.20-64}$), which is estimated to have an impact of 8,3 p.p. in the period 2022-2070. In

contrast, the Benefit Ratio ($BR = \frac{Av.Pension\ Income}{GDP}$) is expected to contribute negatively to

pension expenditure as a share of GDP by about 3,8 p.p. thanks to the progressive introduction

of the NDC system and the indexation of pensions to inflation. The Coverage Ratio (CR =

$\frac{Numb.Pens.}{Pop.65+}$) will also have a negative impact on the pension expenditure/GDP ratio, at around

3.2 P.P., thanks to the increased eligibility requirements for retirement introduced by automatic

adjustment mechanisms. The formula $\frac{Pop.20-64}{Hours\ Worked}$ measures the labor intensity or employment

efficiency, reflecting how many people in the working-age population (20-64) are contributing

to hours worked. It is a key factor in connecting demographic shifts to labor market

performance. Let "Hours Worked" include only hours worked by those aged 20-64, the

decomposition would align exactly.

It is important to underline the crucial role of the replacement rate in ensuring the sustainability of the pension system. Currently, the replacement rate for those still using the mixed system

(NDC and DB) is 79%, while for those who only use the NDC system it drops to 59%. The

latter is estimated to fall further to 46% by 2050, then gradually rise to 52% in 2070. This

comparison provides valuable insights for my analysis and tools to assess the effectiveness of reforms.

- *Pension Reform in the European Union from the Early 2000'*

The European Commission's report (2016) is a key resource for understanding the evolution of pension systems in the EU in response to policy changes and economic challenges. Using a multi-temporal framework, it highlights critical insights relevant to the sustainability of these systems.

According to the response to the 2008 crisis, the report contrasts Pay-As-You-Go (PAYG) and capitalization schemes. While capitalization schemes allow workers to build pensions through investments, the 2008 crisis exposed their vulnerabilities, including negative returns and poor asset diversification. Eastern European countries like Poland and Hungary reversed or scaled back privatization efforts, while Slovakia made private participation optional, demonstrating the systemic risks of these schemes during economic downturns.

Successive forecasts (2001-2015) reveal declining projected increases in pension expenditure by 2040, reflecting the impact of structural reforms such as raising retirement ages and transitioning to contribution-based systems. Post-2040 trends vary, with some projections anticipating declining expenditure and others predicting continued growth until 2060, emphasizing the influence of reforms and evolving assumptions like migration and labor participation (Figure 1).

The contrasting experiences of PAYG and capitalization schemes during crises highlight the need for careful consideration of systemic risks in pension sustainability. These findings support the work project's focus on using forecasting models and demographic variables to evaluate the long-term sustainability of the Italian pension system.

Finally, the report introduces a financial stability index for the pension system, called the Financial Sustainability Indicator (FGI), which also applies to non-contributory schemes (PAYG). This index is derived from the financial balance sheet constraint, expressed by the following equation:

$$\bar{C}_t \cdot Cont_t = \bar{P}_t \cdot Pens_t$$

The latter indicates that the average amount of pension contributions (\bar{C}_t), multiplied by the number of contributors ($Cont_t$), must be equal to the average amount of pensions (\bar{P}_t) multiplied by the number of pensioners ($Pens_t$). Using this relationship, we can calculate the FGI as follows:

$$FGI = \overline{FR}_t \cdot \overline{DR}_t - 1$$

A pension system is therefore in financial equilibrium when the FGI is equal to 0. A negative value indicates an imbalance, while a positive value suggests a surplus. The second part of the FGI equation shows how sustainability depends on the Financial Ratio ($\overline{FR}_t = \frac{\bar{C}_t}{\bar{P}_t}$), average contributions to pensions, and the Demographic Ratio ($\overline{DR}_t = \frac{Cont_t}{Pens_t}$), contributors to pensioners. Improving sustainability requires actions such as increasing contributions, raising retirement ages, or expanding the tax base through policies promoting higher birth rates or immigration. This framework provides a quantitative foundation for assessing the long-term sustainability of pension systems.

Related Studies

Flehtner and Middelanis (2024) show that external shocks influence public social spending, with outcomes shaped by policies and governance. Using SVAR and LP models, they emphasize the need for institutional reforms to achieve sustainability. This aligns with my work project on the Italian pension system, which examines the impact of economic and demographic

shocks while evaluating the role of governance and past reforms, such as the Dini (1995) and Fornero (2012) laws, in ensuring fiscal sustainability and inter-generational equity.

Alloza *et al.* (2024) examine public debt sustainability under macroeconomic uncertainty, highlighting the risks of rising fiscal pressures, mainly due to an aging population, and the importance of fiscal consolidation. This aligns with my work project on the Italian pension system, as both explore the impact of demographic and economic shocks and emphasize the need for structural reforms to ensure long-term fiscal stability using dynamic models like VAR and LP.

Cardoso and Carvalho (2021) find that spending-based fiscal consolidations increase income inequality, while tax-based adjustments have no significant effect. Using LP models, the study highlights the importance of policy design in mitigating economic shocks. This finding supports my focus on targeted reforms, particularly the Dini (1995) and Fornero (2012) laws, which seek to balance fiscal sustainability with equality. These policies demonstrate how dynamic responses to economic pressures can address both short-term fiscal goals and long-term equality considerations.

Liang and Tussing (2019) show that procyclical health spending – expanding in booms but contracting in recessions – harms population health, reducing life expectancy in developing countries. The study highlights the need for countercyclical strategies and institutional reforms to ensure stability. This aligns with my analysis of the Italian pension system by demonstrating how proactive policy measures, such as countercyclical reforms, are critical for sustaining social systems amidst demographic pressures. The use of VAR and LP models in both studies reinforces their methodological parallels.

Reynolds and Avendano (2018) highlight that higher social spending, mainly on education and incapacity programs, significantly improves life expectancy across OECD

countries, while healthcare spending alone has limited effects. This underscores the role of targeted social policies, mirroring my project's emphasis on the broader societal dimensions of pension system sustainability. Both studies use structural reforms and dynamic modeling to evaluate how long-term social outcomes can be balanced with fiscal stability.

Kok *et al.* (2015) examine the financial and social trade-offs between residential and home care in the Netherlands, finding that home care is less costly for public finances, while residential care enhances happiness for elderly individuals. It also highlights how adverse payment system incentives favor residential care despite its higher societal costs. This study aligns with my analysis on the Italian pension system, as both address the balance between fiscal sustainability and social well-being under demographic pressures. While the article focuses on elderly care, my work project explores inter-generational equity and financial sustainability in pension systems, with a shared emphasis on demographic factors and systemic incentives.

Liu and Zhang (2023) investigate the impact of age-specific financial incentives on private health insurance take-up among elderly Australians, showing that higher rebates modestly increase participation, mainly among low-income individuals. This aligns with my study on the Italian pension system, as both explore how policy incentives affect social systems under demographic pressures. While the article focuses on financial incentives for health insurance, my work project evaluates pension system reforms, such as the Dini (1995) and Fornero (2012) laws, in balancing fiscal sustainability and intergenerational equity. Both studies emphasize the importance of targeted policies and use dynamic approaches to assess the long-term impacts of policy interventions.

Abrahamsen and Grøtting (2022) examine the impact of expanded formal elder care in Norway on the health of adult daughters, showing a significant reduction in sickness absences – mainly for musculoskeletal and psychological disorders – among those in less flexible jobs, but no

evidence of long-term health improvements. This relates to my study on the Italian pension system by addressing the effects of demographic pressures on social systems and the role of policy interventions in mitigating adverse outcomes. While the article focuses on formal care and caregivers' health, my work project examines the resilience of the pension system under economic and demographic shocks. Both studies emphasize the importance of targeted reforms and use dynamic models, such as VAR and Local Projection (LP), to analyze policy impacts and ensure long-term sustainability.

Gabani *et al.* (2022) analyze how transitions to government-financed systems improve health outcomes, while social health insurance systems offer limited benefits due to higher costs. This aligns with my study on the Italian pension system, as both highlight the role of policy reforms in ensuring sustainability and equity under demographic pressures. While the article focuses on health financing, my work project examines the impact of economic and demographic shocks on pensions, emphasizing the importance of reforms like the Dini (1995) and Fornero (2012) laws for achieving long-term fiscal and social resilience.

Jimon *et al.* (2021) examine pension sustainability using GMM and VAR models, closely aligning with my research approach. Analyzing Hungary, Poland, and Slovakia, they highlight the pivotal role of GDP growth and the contributory base in ensuring long-term stability while stressing the need for reforms like raising the retirement age or expanding the workforce. However, they caution that such measures must balance fiscal sustainability with pension adequacy to prevent increased poverty and social costs, advocating for comprehensive policies that address both financial and social objectives.

Methodology

In this section, the methodology of my research will be illustrated. It encompasses data collection, model implementation, and impulse response function analysis.

Data Collection

For the purposes of my research, and considering previous studies, I decided to include the following variables: population, net migration, demographic dynamics, employment rate, unemployment rate, activity rate, fertility rate, life expectancy, pension expenditure in relation to GDP, number of pensioners, GDP, retirement age and productivity index (Figure 2). The time period analyzed is from 1960 to 2024, with annual observations for each variable. This approach was adopted because some variables, such as life expectancy or fertility rate, only have annual data; consequently, for uniformity, all variables will be treated annually.

All variables, with the exception of productivity – calculated as the ratio between GDP in absolute value and the number of active workers – come from the official datasets of ISTAT, the Italian National Institute of Statistics. The choice to use ISTAT data is based on their reliability and completeness, which guarantee an accurate representation of Italian dynamics. The time span chosen represents the maximum period common to all variables and is adequate to capture the main dynamics of the Italian pension system, covering the evolution from the salary system to the latest changes in the retirement age.

The selected variables also make it possible to grasp both demographic trends, such as population aging or migration flows, and labor market dynamics, providing an integrated and in-depth picture of the forces that influence the sustainability of the Italian pension system.

Model Implementation

- *Data Preparation and Model Setup*

The first step to be taken in order to build a VAR is to check if the variables are stationary. The stationarity condition is essential, as it ensures that the mean, variance, and covariance are constant over time, thus achieving statistical validity for the model and a correct interpretation of the results. This verification is carried out through the Dickey-Fuller Test, which allows to verify the presence of unit roots. A logarithmic transformation is applied to the variables before

proceeding with the Dickey-Fuller (DF) test. This transformation is crucial to homogenize the data and reduce potential heteroskedasticity. In addition, it guarantees comparability between variables expressed in different units of measurement, such as percentages and absolute values.

The DF Test reveals that some variables do not meet the stationarity condition, necessitating the use of first differences. After first difference is applied, the test confirms stationarity for all variables except population. The population variable exhibits cyclical components and dynamics that do not follow a clear deterministic trend, making it challenging to model as stationary with a single differentiation. To maintain the stability and validity of the model, it has been decided to exclude the population variable at this stage of the analysis.

As a second step, the Lag-Order Selection Criteria is performed (Figure 3), which is essential to identify the optimal number of lags that effectively capture the temporal dynamics between variables. The outputs of Akaike (AIC), Hannan-Quinn (HQIC), and Bayesian Information Criterion (BIC) differ on the number of lags to be adopted, reflecting different approaches. AIC prioritizes model adaptation, accepting more lags to improve predictive capacity, while HQIC and BIC favor a more economical model, reducing the risk of overfitting by choosing fewer lags. After careful analysis and considering the limited number of observations in the dataset (less than 100), we choose to adopt the criterion indicated by the AIC, which suggests the use of one lag. This choice is also supported by the Final Prediction Error (FPE), which is lower with the number of lags considered¹.

Estimation

The analysis employs stepwise regression (Figure 4) to identify the most significant predictors of pension expenditure relative to GDP, aiming for a parsimonious, robust model. By

¹ FPE is a criterion that estimates out-of-sample prediction error, i.e. the model's ability to generalize and predict future data. Minimizing FPE ensures a balance between the complexity of the model and its predictive capacity, penalizing overly complex models that risk overfitting the observed data.

combining forward selection and backward elimination, variables are iteratively added or removed based on their p-values ($\leq 5\%$). The resulting model includes GDP, fertility rate, employment rate, and activity rate, variables that are both statistically significant and theoretically relevant. This outcome highlights the strong interaction between economic dynamics, such as employment and activity rates (key to contribution sustainability), and demographic factors like fertility rates, which influence the future contribution base.

To evaluate the model's predictive performance, the Root Mean Squared Error (RMSE) is calculated, showing a value close to zero, which indicates consistency and accuracy. Additionally, the AIC and BIC criteria confirm a good balance between model fit and complexity (Figure 5).

A complementary Principal Component Analysis (PCA) is conducted to address multicollinearity by transforming variables into a smaller number of principal components that capture the most relevant variance (Figure 6). Using the elbow criterion from the scree plot (Figure 7), four components are identified as sufficient to explain most of the data's variance, reaching a cumulative variance of 64.19%. This result is consistent with the stepwise regression output, reinforcing the robustness of the selected variables.

In summary, both techniques confirm the importance of economic and demographic variables in explaining pension expenditure. The integration of stepwise regression and PCA ensures a streamlined yet informative model, capturing the underlying structure of the data while maintaining efficiency and accuracy.

- *Diagnostic Tests*

After selecting the relevant variables and estimating the model, diagnostic tests are conducted to ensure its statistical robustness. The Lagrange Multiplier (LM) Test is used to check for autocorrelation in the residuals, as VAR models assume that residuals are independent over time (white noise), with zero mean and constant variance. If this assumption is violated, the

coefficient estimates become consistent. The test results indicate that with one lag, the null hypothesis of no serial autocorrelation cannot be rejected at the 5% significance level, confirming that a one-lag VAR model is appropriate (Figure 8).

To verify model stability, the eigenvalue stability test is performed. This test ensures that future forecasts are reliable by checking that the model avoids explosive behavior. The results show that all eigenvalues lie within the unit circle, with moduli less than one, confirming the stability of the VAR model (Figure 9).

Finally, the White Test is applied to check for homoskedasticity, ensuring that the variance of errors remains constant. After estimating the VAR(1) and regressing the squared residuals on the explanatory variables, the results show that all p-values exceed the 5% significance level. This indicates no evidence of heteroskedasticity, confirming that the residuals are homoscedastic (Figure 10).

In summary, the diagnostic tests validate the robustness of the model: residuals are uncorrelated, the model is stable, and the errors exhibit homoskedasticity, making it suitable for reliable forecasting and analysis.

Impulse Response Function (IRF)

Before making forecasts across different historical periods, the Impulse Response Functions (IRFs) are analyzed to evaluate how pension expenditure relative to GDP responds to shocks in key variables – GDP, fertility rate, employment rate, and activity rate – within the VAR model over a three-year horizon (Figure 11).

The first IRF examines the response of pension expenditure to a GDP shock. The results show little impact in the short term, with the dependent variable remaining largely stable. An increase in GDP initially drives consumption, investment, and productivity, leading to inflation. Pension system adjustment mechanisms, particularly pension indexation to inflation, increase system

costs proportionally. However, rising tax revenues due to inflation and income growth balance these costs, maintaining overall pension system stability despite GDP fluctuations.

The second IRF assesses the response to a fertility rate shock. While there is a short-term positive impact, the effect quickly fades. This reflects the delayed benefit of higher fertility rates, as newborns do not immediately contribute to the pension system. In the short term, increased aggregate demand (e.g., baby-related spending) may stimulate economic growth, but the real impact occurs in the long term – 25-30 years later – when these cohorts enter the labor market and expand the contribution base, particularly crucial for Italy’s pay-as-you-go system.

The third IRF analyzes the effect of a positive employment rate shock. A slight short-term increase in pension spending is observed, driven by higher contributions from active workers. However, in Italy’s context of economic policy instability, these revenues may incentivize short-term policy adjustments, such as increasing minimum pensions or introducing additional benefits. Such decisions could counteract the positive effects of higher contributions, challenging the system’s sustainability.

The fourth IRF investigates the impact of a positive activity rate shock, which reflects an increase in the working-age population (15-64 years). Unlike the employment rate, the activity rate expands the potential contribution base, improving the ratio between active workers and retirees. Structural dynamics, such as raising the retirement age or earlier labor market entry, contribute to this effect. The shock leads to improved pension system sustainability in the short to medium term, as the broader contribution base enhances social security income. Additionally, higher activity rates stimulate economic growth through increased consumption and investment. However, the effect is short-lived, with the system returning to equilibrium in the medium term.

In summary, the IRF analysis highlights the complex interactions between economic and demographic shocks and the Italian pension system. While GDP and fertility rate shocks have minimal immediate impact, shocks to the employment and activity rates offer short-term improvements, mainly through broader contribution bases. Overall, the system demonstrates a capacity to absorb shocks and maintain sustainability, with long-term effects more dependent on structural demographic dynamics.

Results and Discussion with Related Studies

The work project integrates forecasting and IRFs to evaluate the dynamics of pension expenditure relative to GDP in the Italian pension system. Forecasting, based on a VAR model across multiple base years (2000, 2010, 2015, 2020, and 2025), provides a comprehensive view of variable trajectories over a five-year horizon, capturing the impact of structural reforms and economic-demographic trends (Figure 12-13-14-15-16). While IRFs assess isolated shocks, the broader forecasts highlight persistent structural weaknesses, such as prolonged recovery times after GDP shocks. Inflationary pressures triggered by GDP growth lead to higher pension spending due to indexation, but these effects are counterbalanced by systemic rigidities, including low productivity, inefficient resource allocation, and the emigration of highly skilled workers (“brain drain”), which further deplete the contribution base and limit long-term growth. These rigidities cause the IPS to exhibit increasing instability in each forecast, with longer recovery times and a slower return to equilibrium. Specifically, the four forecasts reveal that GDP shocks result in a progressive weakening of the system’s capacity to absorb economic fluctuations, highlighting the need for structural reforms to enhance resilience and adaptability.

Key demographic challenges, such as a declining fertility rate, emerge as critical constraints on the system’s resilience, reducing the labor market contribution base while amplifying the burden of an aging population. The analysis underscores the urgent need for targeted

interventions. LPs reveal that fertility rate shocks provide long-term benefits but minimal immediate effects due to delayed demographic adjustments, while migration shocks yield quicker, more pronounced positive impacts by expanding the active workforce and contribution base (Figure 17-18). These findings underscore the importance of complementary policies: fertility improvements for long-term stability and migration strategies for immediate relief, provided effective integration measures are implemented.

The IRF analysis further highlights the complex interactions between economic and demographic shocks. Shocks to GDP and fertility rates show limited short-term effects, while employment and activity rate shocks improve short-term sustainability by expanding the contribution base. These insights align with the broader literature on fiscal sustainability. For instance, Flechtner and Middelani (2024) emphasize the role of institutional reforms in managing external shocks, resonating with the need for governance to sustain employment and activity rate improvements. Similarly, Alloza et al. (2024) stress the fiscal pressures of an aging population, which are evident in the Italian system's demographic rigidity and limited recovery capacity. Liang and Tussing (2019) further underline the risks of procyclical spending, highlighting the importance of countercyclical fiscal strategies and reforms to sustain systems under economic shocks, a principle echoed in the Italian context through reforms like Dini (1995) and Fornero (2012).

Further, Cardoso and Carvalho (2021) highlight the importance of well-designed policies to mitigate economic shocks, aligning with reforms like Dini (1995) and Fornero (2012) that aim to balance fiscal sustainability and equity in the Italian pension system. Reynolds and Avendano (2018) emphasize the significance of targeted social policies to address demographic challenges, echoing the need for effective migration strategies to offset the delayed effects of fertility rate improvements. Kok et al. (2015) complement this perspective by demonstrating how adverse incentives in social systems – such as those observed in elder care – can undermine

fiscal sustainability, underscoring the need for systemic adjustments to incentivize efficient resource allocation and equitable outcomes. Additionally, Jimon *et al.* (2021) reinforce the importance of balancing pension contributions and expenditures, highlighting that imbalances risk burdening public finances. Their findings on the significance of GDP growth, employment, and life expectancy as drivers of pension sustainability further validate the VAR-based methodology applied in this study.

In summary, the combined forecasting and IRF analysis underscores the Italian pension system's structural rigidity, demographic challenges, and reliance on well-designed policies and reforms. Addressing these issues requires enhancing productivity, reversing the brain drain, and implementing integrated strategies to improve fertility and migration flows, ensuring a broader and more stable contribution base for long-term sustainability. These findings align with existing research, emphasizing the critical role of structural reforms, dynamic policy interventions, and governance in managing economic and demographic pressures. This includes leveraging lessons from studies like Abrahamsen and Grøtting (2022), which highlight the importance of policy design in mitigating demographic pressures, and Gabani *et al.* (2022), who stress the long-term benefits of transitioning to more sustainable financing systems to stabilize social systems facing similar challenges.

Conclusion

The analysis highlights the structural challenges and transformations that have shaped the Italian pension system, emphasizing the critical need for long-term strategic reforms. Beginning with the Dini Reform, which introduced the contributory system, and followed by the Fornero Reform, which raised the retirement age and tightened automatic adjustment mechanisms, these measures have improved financial stability but remain insufficient to counterbalance worsening economic and demographic trends.

A key finding underscores the systemic roots of Italy's economic stagnation, marked by insufficient investment in technology-intensive sectors, excessive bureaucracy, and high tax evasion. These issues undermine competitiveness, limit innovation, and weaken the State's ability to implement development policies. The predominance of SMEs, which account for 99.4% of entrepreneurial activities, further constrains scalability and innovation, exacerbating low productivity and economic stagnation, factors closely tied to the pension system's sustainability.

Demographic dynamics exacerbate these challenges. Declining fertility rates, stagnant migration flows, and an aging population increase pressure on the pension system by shrinking the contribution base. The absence of policies to incentivize higher birth rates or attract young talent compounds the problem, creating a feedback loop between economic stagnation and demographic deterioration. A more dynamic economy with higher productivity and incomes could both sustain the pension system and foster conditions for higher birth rates and reduced brain drain.

The analysis concludes that the success of future reforms hinges on integrating economic, demographic, and social policies to reduce intergenerational inequalities and enhance Italy's economic competitiveness. Only a proactive and cohesive approach, addressing both structural weaknesses and demographic shifts, can ensure a resilient and sustainable pension system capable of withstanding long-term economic and societal transitions.

Reference

Abrahamsen, Signe A., and Maja Weemes Grøtting. 2023. *Formal Care of the Elderly and Health Outcomes among Adult Daughters*. *Health Economics*.

<https://pmc.ncbi.nlm.nih.gov/articles/PMC10098824/>.

Alloza, Mario, Jorge Martínez-Pagés, Juan A. Rojas, and Iacopo Varotto. 2024. *Public Debt Dynamics: A Stochastic Approach Applied to Spain*. SSRN.

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4897634.

Ardila A., Attanasio O., Barro R.J., Chor D., Costinot A., Ludwig A., Manova K., et al. 2016. *Population Aging and Comparative Advantage*. *Journal of International Economics*.

<https://www.sciencedirect.com/science/article/abs/pii/S0022199616300630>.

Axel H. Boersch-Supan, Alexander Ludwig. 2010. *Old Europe Ages: Reforms and reform backlashes*. https://www.nber.org/system/files/working_papers/w15744/w15744.pdf.

Bovemberg Lans A.. 2018. *Grey New World: Europe on the road to Gerontocracy?*.

https://www.researchgate.net/publication/46513059_Grey_New_World_Europe_on_the_Road_to_Gerontocracy.

Burniaux, Jean-Marc, Romain Duval, and Florence Jaumotte. 2004. *Coping with Ageing*.

OECD iLibrary. https://www.oecd-ilibrary.org/economics/coping-with-ageing_224538175006.

Cardoso, Dante Souza, and Laura Barbosa de Carvalho. 2023. *Effects of Fiscal Consolidation on Income Inequality: Narrative Evidence from South America*. *Empirical Economics*.

https://ideas.repec.org/a/spr/empeco/v64y2023i3d10.1007_s00181-022-02279-5.html.

CEPR. 2006. *Dealing with the new Giants: Rethinking the role of pension funds* | CEPR.
<https://cepr.org/publications/books-and-reports/geneva-8-dealing-new-giants-rethinking-role-pension-funds>.

European Commission. 2016. *Pension Reforms in the EU since the Early 2000's: Achievements and Challenges Ahead*. Economy and Finance. https://economy-finance.ec.europa.eu/publications/pension-reforms-eu-early-2000s-achievements-and-challenges-ahead_en.

European Commission. 2018. *Fiscal Sustainability Report 2018*. Economy and Finance, January 18, 2019. https://economy-finance.ec.europa.eu/publications/fiscal-sustainability-report-2018_en.

European Commission. 2024. *2024 Ageing Report: Italy - Country Fiche*. Accessed December 15, 2024. https://economy-finance.ec.europa.eu/publications/2024-ageing-report-economic-and-budgetary-projections-eu-member-states-2022-2070_en.

European Commission. 2018. *2018 Ageing Report: Italy - Country Fiche*. https://economy-finance.ec.europa.eu/publications/2018-ageing-report-economic-and-budgetary-projections-eu-member-states-2016-2070_en.

Flehtner Svenja, and Martin Middelani. 2024. *The Role of the Commodity Price Boom in Shaping Public Social Spending: Evidence from Latin America*. World Development. <https://www.sciencedirect.com/science/article/pii/S0305750X24001876>.

Gabani Japoco, Marc Suhrcke, and Sumit Mazumdar. 2022. *The Effect of Health Financing Systems on Health System Outcomes: A Cross-Country Panel Analysis*. *Health Economics*. <https://pubmed.ncbi.nlm.nih.gov/36480236/>.

Garibaldi, Pietro, and Tito Boeri. 2016. *A Clash of Generations? Increase in Retirement Age and Labor*. CEPR Discussion Papers, February 2.

<https://ideas.repec.org/p/cpr/ceprdp/11422.html>.

Garibaldi, Pietro. 2017. *Closing the Retirement Door and the Lump of Labor*.

https://sites.carloalberto.org/garibaldi/doc/papers/Lump_of_Labor_26may_2017.pdf.

Igor Guardiancich. 2013. *Pension reforms in Central, Eastern and Southeastern Europe:*

From Post-Socialist transition to the global financial crisis | request PDF. Accessed

December 15, 2024.

https://www.researchgate.net/publication/235944918_Pension_Reforms_in_Central_Eastern_and_Southeastern_Europe_From_Post-Socialist_Transition_to_the_Global_Financial_Crisis.

Kok L., Berden C., Sadiraj. K. 2014. *Costs and Benefits of Home Care for the Elderly versus Residential Care: A Comparison Using Propensity Scores*. The European journal of health economics : HEPAC : health economics in prevention and care.

<https://pubmed.ncbi.nlm.nih.gov/24390144/>.

Liu, Judith, and Yuting Zhang. 2023. *Elderly Responses to Private Health Insurance Incentives: Evidence from Australia*. Health economics.

<https://pubmed.ncbi.nlm.nih.gov/37641496/>.

Lopreite M., Mauro M.. 2017. *The Effects of Population Ageing on Health Care Expenditure: A Bayesian Var Analysis Using Data from Italy*. Health policy (Amsterdam, Netherlands).

<https://pubmed.ncbi.nlm.nih.gov/28392027/>.

MIMIT (Ministero delle Imprese e del Made in Italy). 2024. *Le PMI e il Sistema Produttivo Italiano*. https://www.mimit.gov.it/images/stories/Dip_Internazionalizzazione/sistema-produttivo-e-dati-congiunturali-pmi.pdf.

Ministero dell'Economia e delle Finanze. 2017. *The 2018 Ageing Report: Economic and Budgetary Projections for the EU Member States (2016-2070)*. Economy and Finance.

https://economy-finance.ec.europa.eu/publications/2018-ageing-report-economic-and-budgetary-projections-eu-member-states-2016-2070_en.

Pérez-Moreno, S., D.M. Cutler, S. Hopkins, G. Cruces, S. Bhalotra, G. Quaglio, E. Ongaro, et al. 2018. *The Cyclicalities of Government Health Expenditure and Its Effects on Population Health*. Health Policy.

<https://www.sciencedirect.com/science/article/abs/pii/S0168851018306420>.

Ragioneria Generale Dello Stato. 2024. *Ragioneria Generale dello Stato - Ministero dell'Economia e delle Finanze - Spesa pensionistica - Anno 2024*.

https://www.rgs.mef.gov.it/VERSIONE-I/attivita_istituzionali/monitoraggio/spesa_pensionistica/index.html.

Rand Corporation. 2003. *The Demographic Dividend: A New Perspective on the Economic Consequences of Population Change*. Accessed December 15, 2024.

https://www.rand.org/pubs/monograph_reports/MR1274.html.

Reynolds, Megan, and Mauricio Avendano. 2018. *Social Policy Expenditures and Life Expectancy in High-Income Countries*. American journal of preventive medicine.

<https://pubmed.ncbi.nlm.nih.gov/29254555/>.

Rivista Inarcassa. 2024. *Quando l'invecchiamento della popolazione incide sulla sostenibilità dei sistemi di welfare*. <https://rivista.inarcassa.it/-/quando-l-invecchiamento-della-popolazione-incide-sulla-sostenibilit%C3%A0-dei-sistemi-di-welfare>.

Rivista Italiana di Public Management. 2021. *Invecchiamento demografico e Sostenibilità della Spesa*. https://www.rivistaitalianadipublicmanagement.it/wp-content/uploads/2021/06/05_RIPM_V3-N2_Dialoghi_Art.5.pdf.

Appendix

Figure 1 - Multi-temporal Forecast

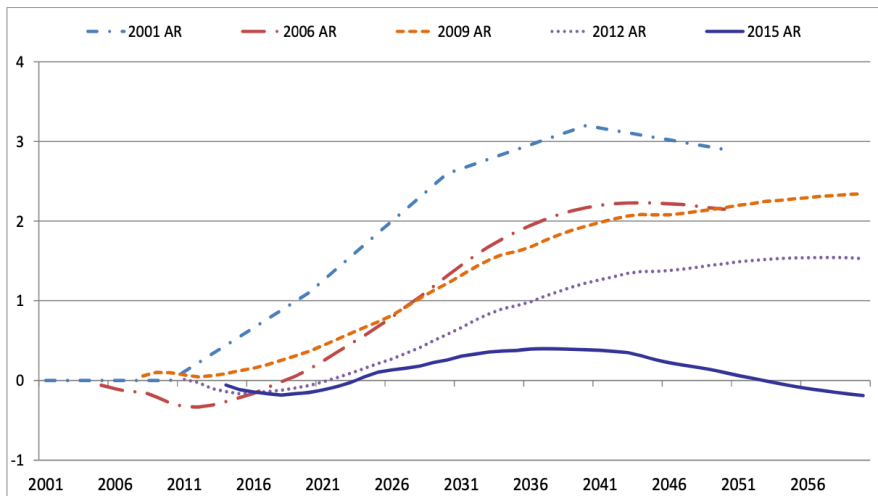


Figure 2 - Variables

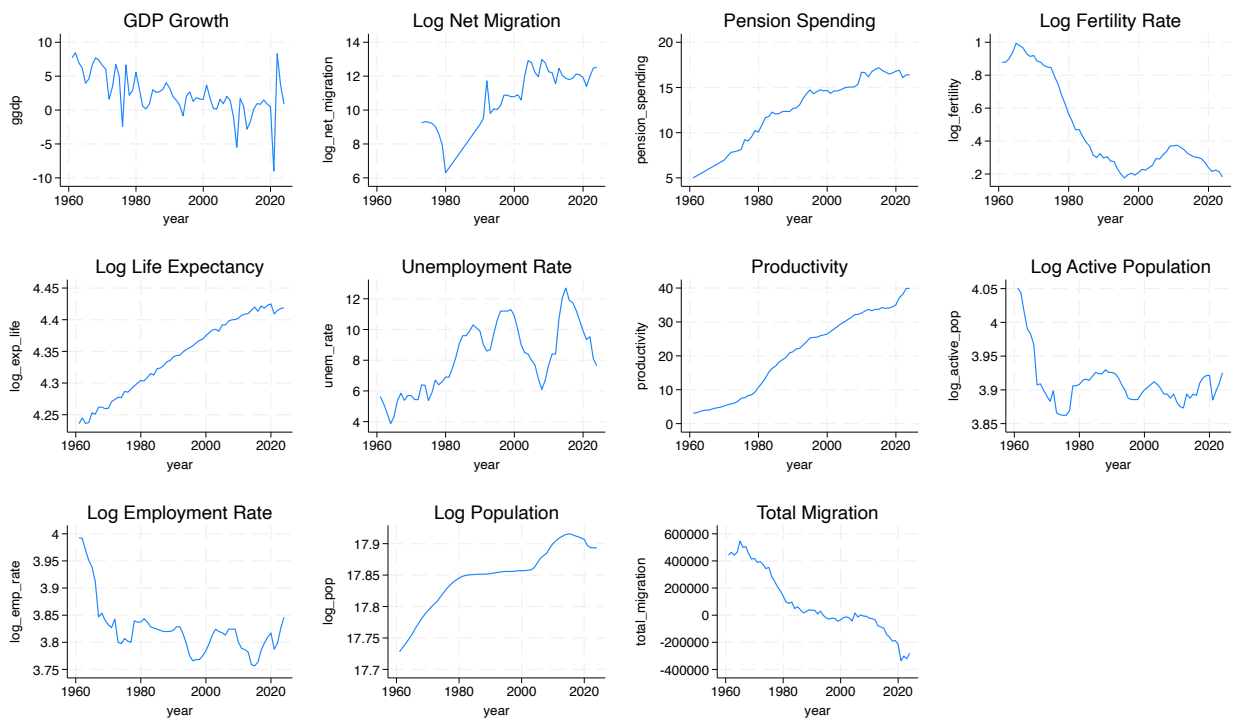


Figure 3 - Lag-Order Selection Criteria

Lag-order selection criteria

Sample: 1963 thru 2024

Number of obs = 62

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1090.69				1.3e-30	-34.7966	-34.635	-34.3849*
1	1317.77	454.15	144	0.000	9.3e-32*	-37.4764*	-35.375*	-32.1243
2	1446.34	257.13*	144	0.000	2.5e-31	-36.9786	-32.9374	-26.686

* optimal lag

Endogenous: **D_pension_spending D_ggdp D_log_fertility D_log_exp_life
D_unem_rate D_log_net_migration D_log_tot_migration D_log_pop
D_log_emp_rate D_log_active_pop D_log_retirees D_productivity**

Exogenous: **_cons**

Figure 4 - Stepwise Regression

```
1 . stepwise, pr(0.05): regress D_pension_spending D_ggdp D_log_fertility D_log_exp_life D_unem
> _rate D_log_net_migration D_log_tot_migration D_log_pop D_log_emp_rate D_log_active_pop D_l
> og_retirees D_productivity
```

```
Wald test, begin with full model:
p = 0.9522 >= 0.0500, removing D_log_net_migration
p = 0.9003 >= 0.0500, removing D_unem_rate
p = 0.6954 >= 0.0500, removing D_log_tot_migration
p = 0.4615 >= 0.0500, removing D_log_exp_life
p = 0.1481 >= 0.0500, removing D_log_retirees
p = 0.1215 >= 0.0500, removing D_productivity
```

Source	SS	df	MS	Number of obs	=	64
Model	4.08264375	5	.816528751	F(5, 58)	=	14.02
Residual	3.37841358	58	.05824851	Prob > F	=	0.0000
				R-squared	=	0.5472
				Adj R-squared	=	0.5082
Total	7.46105734	63	.118429482	Root MSE	=	.24135

Figure 5 - Information Criteria, lags(1)

```
1 . estat ic
```

Akaike's information criterion and Bayesian information criterion

Model	N	ll(null)	ll(model)	df	AIC	BIC
var_model_r	63	.	761.3153	42	-1438.631	-1348.619

Note: BIC uses N = number of observations. See [\[R\] IC note](#).

Figure 6 - Principal Component Analysis

```
1 . pca D_ggdp D_log_fertility D_log_exp_life D_unem_rate D_log_net_migration D_log_tot_migrati
> on D_log_pop D_log_emp_rate D_log_active_pop D_log_retirees D_productivity
```

```
Principal components/correlation          Number of obs   =      64
                                          Number of comp. =      11
                                          Trace           =      11
Rotation: (unrotated = principal)       Rho             =      1.0000
```

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.27013	.554931	0.2064	0.2064
Comp2	1.7152	.139285	0.1559	0.3623
Comp3	1.57592	.0767802	0.1433	0.5056
Comp4	1.49914	.343682	0.1363	0.6419
Comp5	1.15546	.276051	0.1050	0.7469
Comp6	.879404	.112667	0.0799	0.8268
Comp7	.766737	.291396	0.0697	0.8965
Comp8	.475341	.0349723	0.0432	0.9398
Comp9	.440369	.219817	0.0400	0.9798
Comp10	.220552	.218804	0.0201	0.9998
Comp11	.00174806	.	0.0002	1.0000

Figure 7 - Screen Plot

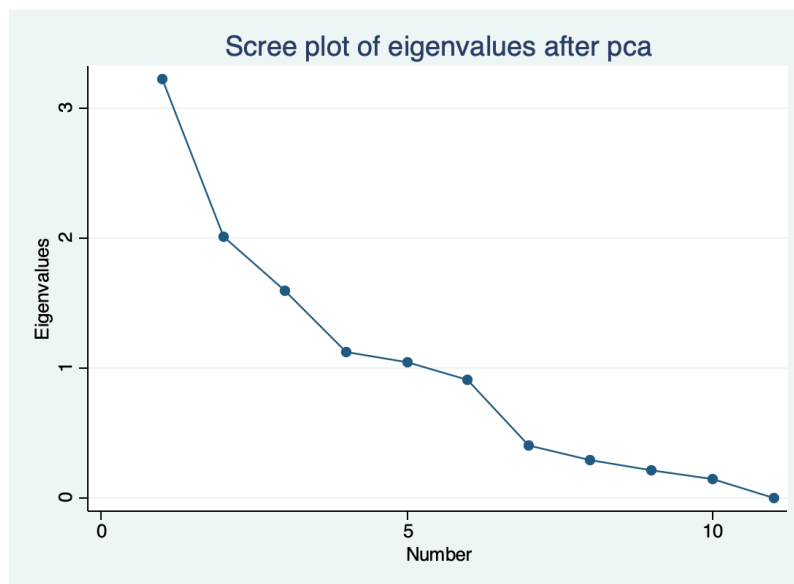


Figure 11 - Impulse Reponse Function

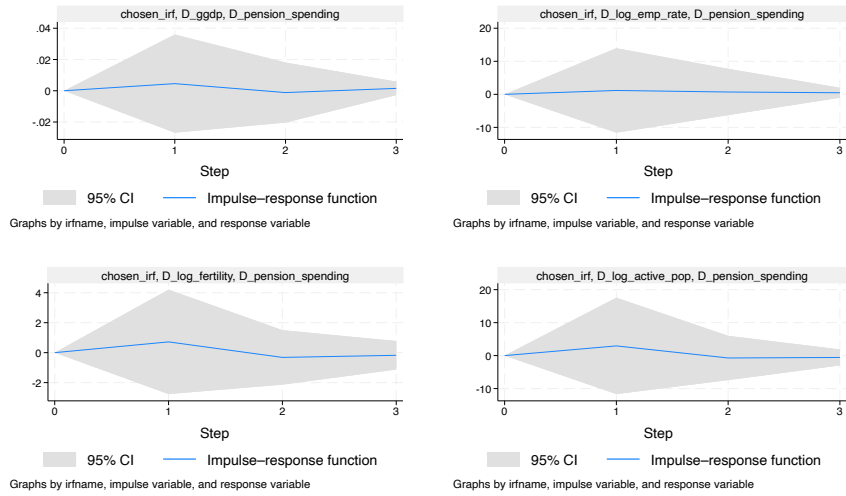


Figure 12 - Forecasting from 2000

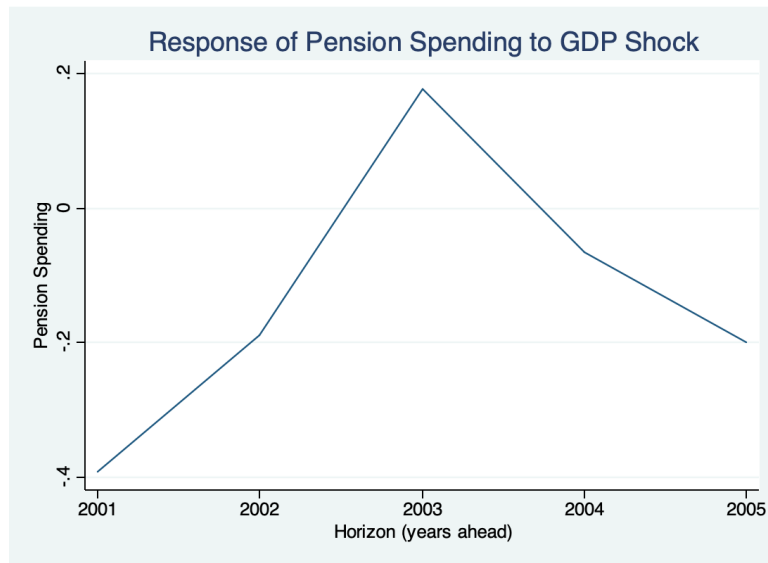


Figure 13 - Forecasting from 2010

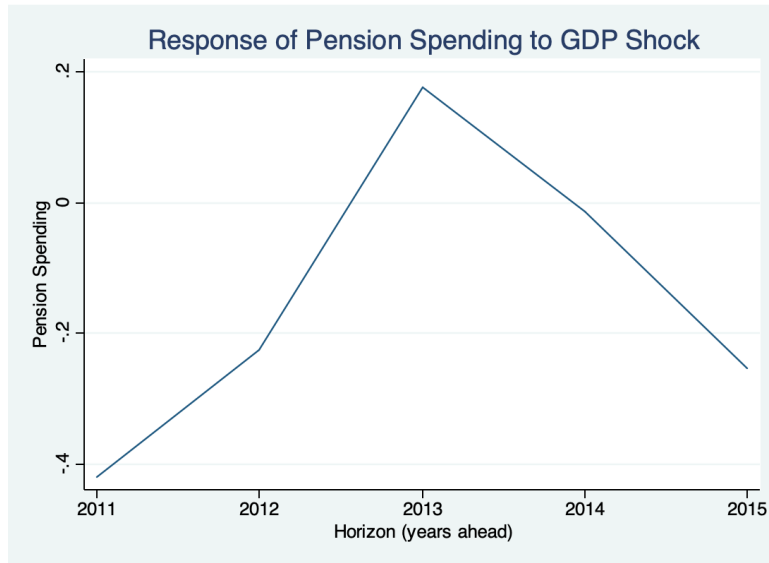


Figure 14 - Forecasting from 2015

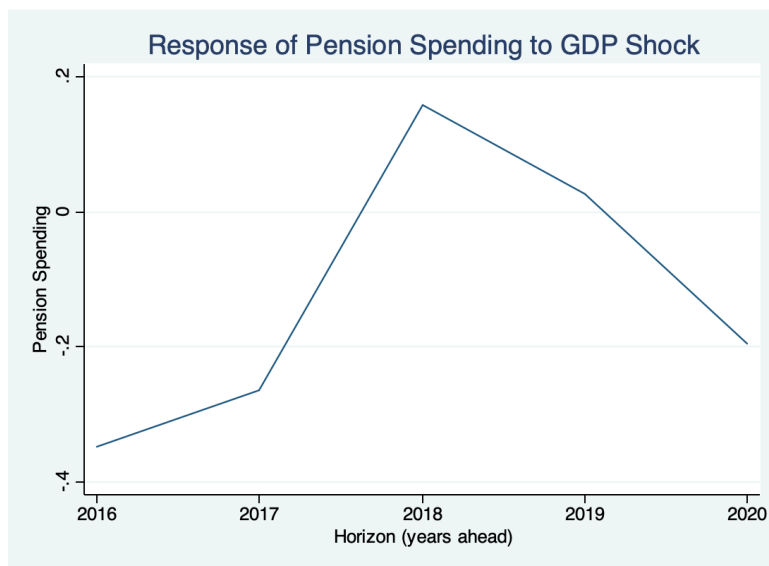


Figure 15 - Forecasting from 2020

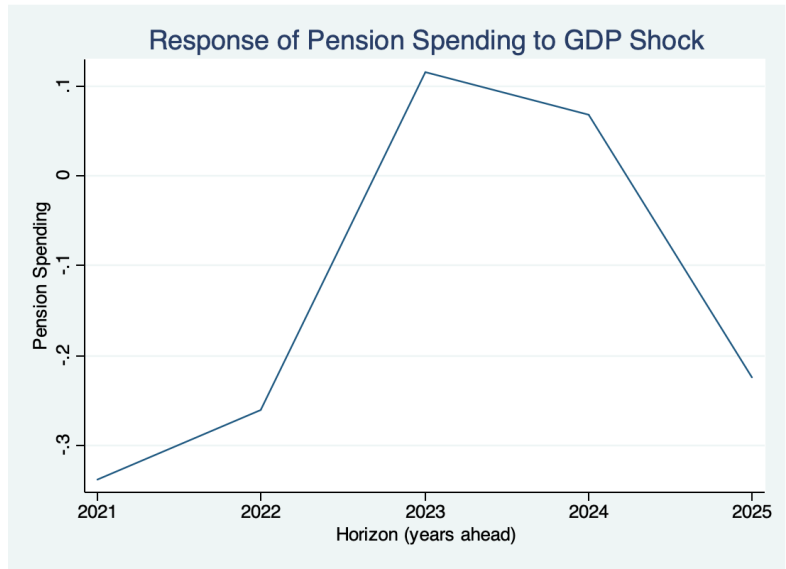


Figure 16 - Forecasting from 2025

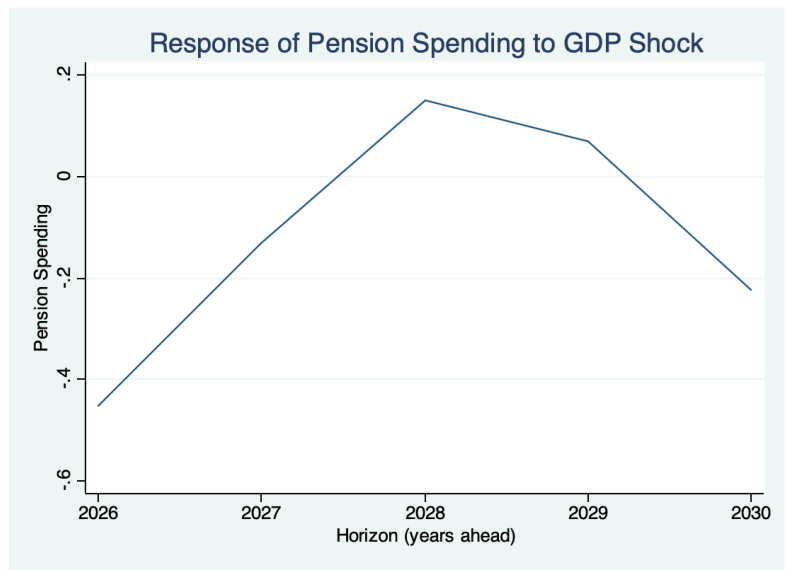


Figure 17 - Local Projection on Fertility Rate

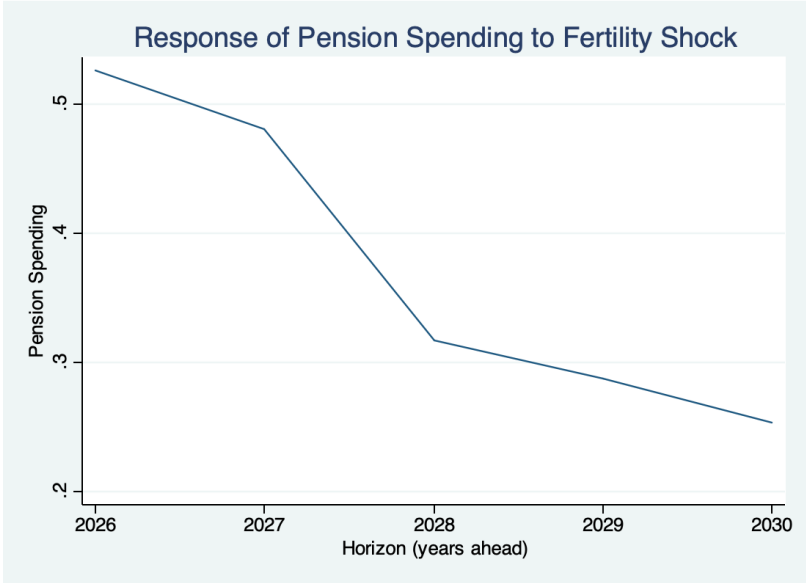


Figure 18 - Local Projection on Net Migration

