LUISS

Degree Program in Economics and Business

Course of Statistics

Modelling the Evolution of the Italian Public Pension System

Prof. Marco Perone Pacifico

Supervisor

Silvia Morando-268161

Candidate

Academic Year 2023/2024

Table of contents:

Introduction

Over the last several decades the Italian public pension system has undergone profound reforms in response to economic challenges, demographic changes, and the need to ensure long-term financial sustainability. As a country with one of the oldest populations in the world, Italy's pension system is under significant pressure from increasing life expectancy, declining birth rates and a shrinking workforce. Legislative changes such as the Amato (1992) and Dini (1995) reforms, gradually shifted the system towards a more balanced and equitable model, where pension benefits were increasingly tied to contributions made over a worker's lifetime. These changes were not only necessary to control public spending but also to address intergenerational equity issues, ensuring that future retirees would receive pensions based on contributions made over the entire working life rather than benefits tied to final years' earnings.

Modelling the future trajectory of Italy's pension system has become an essential tool for policymakers and economists to assess the sustainability of the pension system and the impact of reforms over time. Medium- and long-term projection models provide valuable insights into how the pension system will evolve, helping to predict valuable data like future pension costs, the ratio of workers to pensioners and the broader macroeconomic implications of demographic trends.

This thesis focuses on the application of projection models to evaluate the evolution of the Italian public pension system. It begins by outlining, in the first chapter, the system's structure and its historical transition from a wage-based to a contribution-based scheme. The subsequent chapter, discusses in detail the main institutions participating both in the pension system and in the projection models, such as INPS and ISTAT. It then explores the structure of the two projection models, developed respectively by the State General Accounting Department and the Department of the Treasury, which use demographic and macroeconomic variables to predict future statistics. These models allow for a detailed analysis of how different reforms impact various population groups, projecting in the final chapter outcomes such as pension adequacy, retirement age and the overall long-term financial sustainability of the system. Through the results of the projection models, this thesis aims to offer insights into the circumstances that will be faced by policymakers as they navigate the future of public pensions in an increasingly aging society.

Chapter 1

The Italian public pension system

1.1 A brief overview

Nowadays, the Italian public pension system is structured according to a contribution-based scheme: the contributions that workers and companies make to pension funds are used to pay the pensions of those who have left the workforce and are therefore retiring. To meet the payment of future pensions workers are not required to autonomously accumulate financial reserves during their work life. In a system organized according to this scheme, the income stream represented by contributions must correspond with the amount of expenditure represented by pensions paid. Over the past three decades, the Italian social security system has been affected by structural reforms aimed at:

- the progressive control of public spending on pensions, to ensure that it does not become too significant in relation to Gross Domestic Product;
- the establishment of a complementary pension system to support the public one;
- the introduction of some elements of flexibility to exit the labour market by also taking advantage of the complementary pension system [1]

These structural reforms are all tailored to take into account demographical and economical challenges such as decreasing fertility, aging of the population, unemployment and public debt. To understand the importance of these reforms and the shape the Italian public pension system takes today, it is important to summarize the most important stages of its development.

1.2 The historical evolution of the Italian pension system

Following a deceleration in economic development during the 1970s mainly caused by the oil crisis (1973-1976), in the 1980s awareness spread in most industrialized countries regarding the need to rebalance public accounts by downsizing current spending. In Italy, a manoeuvre to correct budget deficits was implemented only at the end of the decade. Consequently, at the beginning of the 1990s, structural reforms were initiated that also affected the pension sector. Most welfare regulatory interventions aimed to limit the overall costs of the system and attempted to increase financial resources through contributions after demographic changes and the resulting growing mismatch between cash inflows and outflows started becoming significant.

Until December 1992 a worker registered with INPS (*Istituto nazionale della previdenza sociale*, the Italian National Institute for Social Security) received a pension, the amount of which was linked to the remuneration earned in the last years of work. With an average revaluation of 2 percent for each year of contribution, for 40 years of deposits, a pension was paid that corresponded to approximately 80 percent of the salary received in the last period of employment (replacement rate). Also, the pension paid was revalued keeping in mind the increase in average prices and real salaries. [1] [2]

1.2.1 The "Amato reform"

The first significant reform of the pension system was introduced in 1992 with the "Amato reform" which gradually increased the retirement age reaching a maximum of 65 years for men and 60 years for women. The minimum years of contributions increased to 35 years for all categories. This represented a major leap compared for example to government workers who required only 20 years of contributions before the reform. Additional limits for people trying to obtain both a pension and job income were introduced and the automatic revaluation of pensions paid was limited only to the increase of average prices. For new workers, the average income level used to assess the pension amount refers to the entire working life of the worker instead of it being the average income in the last 10 to 15 years. Moreover, in case a pension was below the "minimum pension" level, the chance of receiving an additional amount to reach it was dependent on a household income check that also considered the spouse's income. [1] [2]

With the Amato reform, the generosity of the Italian pension system started to become more close-fisted especially with the new generations of workers compared with the previous ones. Indeed, this reform tried to correct the system by reducing and correlating pensions to the effective work life of the single workers, creating a basis for an improved intergenerational equality after years of "inconsiderate usage" of the public pension system characterized by interventions that augmented and extended pensions for the purpose of social consensus. [3] However, the Amato reform left two key problems unsolved: contribution rates remained excessively high and the system would not be able to cope with the effects of the demographic transition. [4]

1.2.2 Decreto legislativo n. 124

In 1993, following the need to introduce an organic regulation to the complementary pension system, with the *Decreto legislativo n.124* (Legislative decree n.124) the Italian pension system stopped being a “single pillar” system relying on mandatory participation in the public pension system. Following, two additional “pillars” were introduced: the pension funds and the individual retirement accounts. [2]

1.2.3 The “Dini reform”

A new pivotal reform arrived in 1995 with the “Dini Reform” which changed the retribution-based system to the contribution-based system. The difference between the two regimes is substantial. As previously mentioned, in the retributive regime the pension corresponds to a percentage of the worker's salary which in turn depends on seniority, contributions and wages, particularly those received in the last period of working life which tend to be the most favourable. In the contributory regime, on the other hand, the pension amount depends on the amount of contributions paid by the worker over the entire working life. The transition from one calculation regime to the other took place gradually, distinguishing workers according to their contribution seniority. The reform applied a pure contribution-based system only to workers who had never paid contributions before January 1996 with the effect of providing a pension to future retirees that would be approximately 50 percent of the last income at retirement age, compared with 80 percent of the previous system. For workers who, on 31 December 1995, already paid contributions for at least 18 years a defined wage-based scheme was maintained, while those who were not new workers but paid contributions for less than 18 years took part in a blended system where the pension would be assessed partly using a defined contribution scheme and partly by a defined wage scheme. Additionally, the average income of the last years of contribution was not the only metric used to assess the amount of the pension, but also the sum of contributions ever paid during the working life and their revaluation mattered. [2]

The reform put in place a system with better steady-state economic properties than the Amato system: individual actuarial soundness, a modest incentive to postpone retirement, a closer link between contributions and pensions, and a more uniform treatment of different categories of workers. The new system was supposed to reduce the long-term ratio of pensions to GDP boosting savings from various fronts including a moderate reduction in pensions of dependent workers, substantial reduction in pensions of self-employed workers and a reduction in the ratio of pensioners to contributors due to incentives promoting retirement postponement. On the other hand, it left in place high contribution rates and remained vulnerable to demographic changes. [4]

1.2.4 The early 2000s

In 2001, the Berlusconi government increased the minimum pension's monthly amount to one million liras. While in 2004 the "Maroni reform" increased the requirements to apply for retirement. The minimum amount of contributions necessary to retire without age limits remained at forty years. In contrast, old-age pensions now required at least five years of contributions to the pension system and were no longer granted by simply reaching 65 and 60 years of age respectively for men and women. In 2004, a cut on more generous pensions (*contributo di solidarietà*: solidarity contributions) to finance the payment of other pensions was adopted for the first time and used in the following years for the same scope. Also worth mentioning is the "Prodi reform" which introduced the so-called "quotas" for access to the retirement pension, determined by the sum of age and years worked. [1] [2]

1.3 Current framework

Following the economic crisis of 2008 which caused the GDP and therefore the government's cash inflow from tax revenue to decrease, the Italian public pension system was severely weakened. As previously mentioned since 1995, the first pillar of the system progressively turned from a pure defined wage-based system to a defined contribution system for the new workers and a blended system for part of the previous generations of workers, whose pensions were in part still renumerated as a percentage of their average income in the last years of work. Following this shift, contributions that were supposed to be invested to ensure future pensions of current workers were used to cover short-term payments (pay the current retirees). Therefore, the future pensions of current workers would be assessed according to their contributions even if there was no collateral in the pension system. The consequence of this structure is that the sustainability of the system still relied on the age dependency ratio: the ratio between the number of individuals over 65 years old and those of working age. [2]

1.3.1 The "Fornero reform"

"The Fornero reform" in 2011 changed the Italian pension system substantially providing it its current shape, the first intervention being the switch to Notional Defined Contribution (NDC) rules for the computation of pension benefits for all workers in Italy. Participants in the pension system are categorized into two groups based on their contribution seniority: "Pure NDC" for workers with no seniority before 1996, whose benefits are entirely calculated using the NDC rules; "Mixed" for workers with seniority before 1995, whose benefits are calculated using the NDC rules pro-rata for all years of seniority only after a pre-determined year. Therefore, the system no longer applies a pure defined wage-based scheme for any worker. A second intervention of the Fornero reform regarded retirement age with the purpose of aligning all the categories to the same requirements disregarding job category or gender. However, the innovative aspect of this reform, is the self-adjustment mechanism of retirement age according to the life expectancy of the Italian population. Further interventions included early retirement options comprising a reduction of the pension by 1 percent if the applicant was below the 62 year-old age threshold. [2]

The reform strongly increased financial sustainability of the pension system by postponing the retirement of a large number of workers and increased inter-generational equity in the short-medium run. [5] Although the "Fornero reform" applied further measures to cut public expenditure and to make the pension system more sustainable, the new rules concerning pension calculation, retirement age and early retirement provisions demonstrate that this reform can undoubtedly be seen as an "austerity measure", mainly aimed at saving public spending. At the same time, the reform can also be considered incomplete since the retirement age was raised without providing for measures aimed at promoting the employment of long-term senior unemployed people or at combating youth unemployment. [6]

To complete the analysis of the current situation of the Italian pension system, it is important to focus on the contributions requested to the participants. In 2020, employees contributed 33 percent of their income. For the self-employed, this contribution equals 20 percent. Other groups have different percentages that adjust from year to year. However, there is a limit on the annual contribution of an employee equal to a percentage of the "maximum annual income". The high age dependency ratio and the aging of the Italian population require continuous adjustment of the parameters of the pension system. Consequently, the contributions required to current workers tend to be higher than those of other countries. [2]

		Retirement Age						
		Old age pensions				*Seniority pensions*		
		Minimum retirement age			*Minimum years of contributions*	*Minimum years of contributions*		
		Private sector	Public sector	Self-employed		Private sector	Public sector	Self-employed
Pre-1992 regime	**All workers**	60(55)	65	65(60)	15	35	20	35
Post-1997 regime	**Old**	Progressively rising to 65(60)	65	65(60)	Progressively rising to 20	40 before age 57 35 after age 57		40 before age 58 35 after age 58
	Middle-aged	Progressively rising to 65(60)	65	65(60)	Progressively rising to 20	40 before age 57 35 after age 57		40 before age 58 35 after age 58
	Young	Subject to incentives: 57-65			5	Abolished		

		Pension Award Formula		
		Private sector	*Public sector*	*Self-employed*
Pre-1992 regime	**All workers** *Earnings model*	2% × years of contributions × average of the last 5 years of earnings	[2.2 - 2.5%] × years of contribution × last year of earnings	2% × years of contributions × times average of the last 10 years of earnings
Post-1997 regime	**Old** *Earnings model*	Gradually to 2% × years of contribution × average of last 10 years of earnings	Gradually to 2% × years of contribution × average of last 10 years of earnings	Gradually to 2% × years of contribution × average of last 15 years of earnings
	Middle-aged *Pro rata model*	Earnings model before 1995, contribution model after 1995.		
	Young *Contribution model*	Contributions rate (33% for employees and 20% for self-employed) is capitalized on the basis of 5-years moving average of GDP growth. The capitalized sum is then multiplied by a coefficient that varies by retirement age, taking into account life expectancy.		

Table 1 retirement age and pension award formula before and after Amato and Dini reform [7]

Year	Time frame	Men	Women
2012	From 1 January 2012 to 31 December 2012	42 years and 1 month	41 years and 1 month
2013	From 1 January 2013 to 31 December 2013	42 years and 5 months*	41 years and 5 months*
2014	From 1 January 2014 to 31 December 2015	42 years and 6 months*	41 years and 6 months*
2015			
2016	From 1 January 2016	42 years and 6 months**	41 years and 6 months**

*Already adjusted for changes in life-expectancy ratio in the Italian population
**To be adjusted for changes in life-expectancy ratio of the Italian population

Table 2 Minimum contribution age for early retirement after the Fornero reform [2]

Chapter 2

Main participants of the pension system

2.1 National Social Security Institute

The Italian Social Security Institute (*Istituto nazionale della previdenza sociale,* INPS) manages almost the entirety of the Italian social welfare, providing insurance for most self-employed workers and employees in the public and private sectors. The institute was established in 1898 with the creation of the *"Cassa Nazionale di previdenza per l'invalidità e per la vecchiaia degli operatori"* (National Social security Fund for Workers' Invalidity and Old Age), with the aim of insuring workers against the risks of invalidity, old age and death. Over time, especially with the Dini and Fornero reforms, the Institute took on an increasingly important role until it became the pillar of the national welfare system by providing citizens with a single interlocutor for all social security and assistance services. This is a consequence of a 20-year process of gradual amalgamation into INPS of all the social security entities, such as INPGI (National Social Security Institute of Italian Journalists), INPDAP (National Social Security Institute for Public Administration Employees) and ENPALS (National Social Security Entity for Performing Arts Workers). [8]

2.1.2 Main activities

INPS manages the settlement and payment of pensions and indemnities related to social security and welfare. Pensions are social security benefits, determined on the basis of insurance relationships and financed by contributions from workers, public companies and private companies. In contrast, welfare or 'income support' benefits protect workers who find themselves in particular moments of difficulty in their working lives and provide support for those with modest incomes and large families. For some of these benefits, INPS carries out the entire allocation process while for others it is only involved in the disbursement phase. INPS also administers the database for calculating the ISE, used by municipalities to grant household and maternity allowances, and the ISEE, which allows eligibility for certain subsidised social benefits. Additionally, INPS performs supervisory tasks, which are carried out through internal and external databases, ensuring compliance with social security and insurance rights and a levelled competitive playing field between companies on the market. With the acquisition of the functions of the former INPDAP management, INPS provides end-of-service and severance pensions as well as credit and social benefits for public administration employees and pensioners.

As of August 2022 the institute presented the following numbers:

- 25.7 million insured workers;
- 1.8 million insured enterprises;
- 21 million pensions paid out;
- 4 million RdC/PdC (citizenship income/citizenship pension) beneficiaries;
- 1.6 million REM (emergency income) beneficiaries;
- 6.7 million CIG (redundancy fund) beneficiaries in 2020, 3 million in 2021;
- 24,326 employees;
- 448 territorial structures;
- over 1.2 billion accesses to the INPS portal. [8]

2.1.3 Monitoring of pension flows

Via statistical observatories, INPS provides to the community the complete map of the evolution of the labour market, of the agricultural and non-agricultural employment structure, of the wage and pension system, and of the beneficiaries of social safety nets and family provisions. [9] Through these data collections INPS also monitors pension flows. The source of the data is the administrative archive backed by the administrative-accounting procedures for the settlement and management of pensions. The statistical unit is represented by in-force pensions: they constitute flow data. The period taken into account in the Observatory is that relating to pensions starting from the two years preceding the data processing. The observatory is updated quarterly.

Subject to monitoring are treatments, liquidated up to the time of data processing with effective date in the previous two years, in the following administrations:

- Employees' Pension Fund
- Direct farmers, sharecroppers and settlers
- Artisans
- Merchants

- Semi-subordinate workers
- Public employees
- Social allowances.

The pension benefits taken into account are:

- Old age pension, pre-retirement pensions, early retirement pensions
- Ordinary disability allowances
- Incapacity pension
- Privileged pension of disability and incapacity
- Indirect pension paid to the surviving family members of a deceased worker
- Survivor’s pension
- Social allowances.

The data are characterised by an elaboration process that includes a series of controls in order to identify and overcome inconsistencies, anomalies and systematic or random errors that may occur in administrative records. [10]

2.2 The Italian National Institute of Statistics

The Italian National Institute of Statistics (*Istituto Nazionale di Statistica*, ISTAT) is a public research organization producing official statistics at the service of citizens and policy-makers. It operates in complete independence and continuous interaction with the academic and scientific communities. The history of ISTAT starts in 1926, with the creation of the Central Institute of Statistics, when the view of statistics as a tool for understanding phenomena, along with the conviction that all surveys should be carried out by a single independent body, started to gain importance. Since 1989 ISTAT has been performing the role of directing, coordinating, and providing technical assistance and training within the National Statistical System (SISTAN), which includes ISTAT and statistical departments of various public bodies. ISTAT is dedicated to generating and distributing reliable, unbiased, transparent and accessible data that reflect the country's social, economic, and environmental conditions. This is done in strict adherence to confidentiality laws.

One of ISTAT's key responsibilities is conducting comprehensive censuses, including those on population and housing, industry and services, and agriculture. Additionally, it oversees most of the surveys in the National Statistical Programme, which encompasses essential surveys and data processing for the nation. As the primary producer of national statistics, ISTAT provides data and shares information with EU statistical authorities and international organizations. Consequently, it is also part of The European Statistical System (ESS) which encompasses: EUROSTAT (the statistical office of the EU), the statistical offices of all the Member States and other institutions producing European statistics. The European Statistical System guarantees that each EU-Member State produces reliable statistics and processes data in such way for them to be comparable among different EU countries. [11]

2.3 State General Accounting Department

The State General Accounting Department (*Ragioneria Generale di Stato,* RGS) is a central review body that provides support to the Italian Parliament and Government. Its main institutional task is to ensure effective planning and rigorous management of public funds. RGS is tasked with maintaining accurate and reliable government fund accounting, as well as auditing and analysing trends in government spending. Among its duties are preparing the annual budget outline, the multi-year government budget outline, and drafting the budget law along with related measures. In addition, during a preliminary audit, it is called upon:

- to express its opinion on any statutory instrument or other piece of legislation drafted by the Government that may have a direct or indirect impact on public financial and economic management;
- to ensure consistent interpretation and enforcement of accounting standards;
- to exercise oversight functions over the financial management of public bodies through inspections.

The State General Accounting Department engages internationally, maintaining relationships with various organizations, including the European Union, its member states, and other countries. RGS represents Italy in numerous intergovernmental committees, councils, and conferences. Additionally, RGS officials participate in conferences and visits to exchange information, methods, and criteria on topics of mutual interest. [12]

2.4 Department of the Treasury of the Italian Ministry of Economy and Finance

The Department of the Treasury (DT) is a department of the Ministry of Economy and Finance that provides technical support for the Government’s economic and financial policy decisions and drafts macroeconomic strategies and policy documents. The DT is tasked with analysing both national and international economic, monetary, and financial matters, as well as managing public debt, issuing government securities and representing Italy in economic and financial discussions internationally. Additionally, the DT oversees the State’s shareholdings, financial interventions in the economy, regulation and supervision of the credit and financial system, and management of State property.

Overall, the Department’s responsibilities include:

- drafting economic and financial planning guidelines;
- analysing national and international economic, monetary and financial issues;
- managing State property;
- managing the internal and external public debt;
- financial management of the State’s shareholdings. [13]

2.5 Sogei

Sogei (*Società Generale d'Informatica S.p.A.*) is an Information Technology company that is fully-owned by the Italian Ministry of Economy and Finance and operates on the basis of the in-house providing organisational model. It provides IT consultancy services for the public administration, in particular for the Ministry of Economy and Finance and the Tax Agencies on the basis of multi-year service contracts. The company's mission, as a strategic partner of the Economic and Financial Administration, is to contribute to the modernisation of the country by actively participating in the process of digital transformation of the Public Administration. For this reason, Sogei is engaged in implementing IT services capable of governing the complexity of the public system, such as the Fiscal Information System and the automation of operational and management processes of various public administrations.

Some of Sogei‘s activities include:

- the dematerialisation of the Public Administration’s document management system;
- the development of methodologies and tools to prevent and counteract evasion, offences, fraud, tax crimes and illegal transactions;
- simulation of national and international socio-demographic and macroeconomic scenarios to support economic policy decisions and assess their impact;
- development and assistance for the enabling platforms necessary for the Italian digital ecosystem. [14]

Chapter 3

Medium- to long-term Projection Models for Pension Expenditure

3.1 The State General Accounting Department projection model

Medium- and long-term projections of public pension expenditure have become an important element in the Italian economic policy debate. They also play a key role in the European Commission's regular assessments of the medium- and long-term sustainability of public finances. The forecasting process of the pension system requires the formulation of ad hoc macroeconomic and demographic scenarios which are based on structural assumptions that may be subject to margins of uncertainty. The result of the process is a projection of medium- to long-term pension expenditure as percentage of GDP.

In this chapter, a model based on two different reference scenarios will be presented: the “National base scenario” and the “EPC-WGA baseline scenario”. The projections and the model following from the two scenarios are developed by the State General Accounting Department , with models updated as of 2024. The prediction process is carried out with the collaboration of Sogei’s department of Forecasting Models and Analysis of Public Finance Statistics.

3.2 National base scenario and Economic Policy Committee baseline scenario

Expenditure forecasts are drawn up on the basis of two different demographic and macroeconomic scenarios, referred to as “National base scenario” and “EPC-WGA baseline scenario” respectively. Both scenarios use the Cobb-Douglas production function for an estimate of GDP. The two scenarios differ in the underlying assumptions regarding both the population dynamics in the medium to long term and the evolution of the factors of production. More specifically, the national baseline scenario incorporates the demographic forecasts produced by ISTAT with 2022 as base-year and includes the population update on 1 January 2024. Despite the methodological revisions and the different trends in the natural and migration balances, these projections substantially confirm those published by ISTAT with 2021 as base-year. As for the macroeconomic assumptions, these are defined on the basis of specific analyses conducted by the State General Accounting Department. Regarding the EPC-WGA baseline scenario, the demographic assumptions are based on the population forecast produced by EUROSTAT with 2022 as base-year and revised to take into account the Italian population as of 1 January 2024. The long-term macroeconomic assumptions are based on those defined at the European level, in the working group on demographic ageing set up by the Economic Policy Committee of the Ecofin Council (Economic Policy Committee - Working Group on Ageing, EPC-WGA), for the “Ageing Report”. Both scenarios incorporate the National Accounts results for 2023, released by ISTAT in its annual report and, for the short-term period between 2024-2027, the macroeconomic assumptions underlying the *Documento di Economia e Finanza* (Economic and Financial Document, DEF) of 2024. [15]

3.2.1 National base scenario

As previously mentioned, the national base scenario, in its demographic component, incorporates the assumptions underlying the Italian population forecast produced by ISTAT. The forecast is based on a stochastic approach, which results in a wide range of population forecasts, each of which is assigned a probability level. However, given the variability of the results, these forecasts are not suitable as a demographic basis for other types of projection processes. To address this problem, in addition to the stochastic simulations, ISTAT has developed a special population forecast, called the "median" population. In fact, this forecast follows the traditional deterministic approach with demographic parameters defined as a function of the median value of the distributions used for the stochastic simulations. In Table 3 it is possible to observe the demographic assumptions made in the RGS report of 2022[1]. In September 2023, ISTAT published the new set of forecasts of the Italian population for the period 2023-2070, thus replacing those published in 2022 with 2022 as base-year. [15] [16]

[1] The table belongs to the previous RGS report from 2022 and hence does not include the population update from January 2024.

		2010	2020	2030	2040	2050	2060	2070
Istat demographic assumptions (1) Median population	Fertility rates	1.46	1.24	1.37	1.45	1.50	1.54	1.55
	Life expectancy							
	- male	79.3	79.8	82.2	83.6	84.7	85.7	86.5
	- female	84.3	84.5	86.2	87.2	88.1	88.8	89.5
	Annual net immigration (thousands)	380	88	136	131	127	124	118
	Elderly dependency ratio(2)	31.1	36.4	44.4	58.8	65.3	63.6	62.8

(1) Istat (2022). "Previsioni della popolazione residente e delle famiglie. Base 1/1/2021".
(2) Population of 65 and over as a percentage of population 15-64. Values in %.

Table 3 Demographic assumptions- National baseline scenario [16]

In relation to the National baseline macroeconomic assumptions, it is presumed that the effects of the ongoing crisis have only a short-term and temporary impact. The structural evolution of labour market variables is influenced by demographic dynamics and an updated database which, in turn, determines the economic activity rate forecast module. This module predicts future activity rates by considering the interaction between factors like schooling, education levels, and participation rates. Also taken into consideration is the recovery from the Covid-19 epidemic crisis characterised by the persistence of supply-side holdups, which have led to a sudden increase in commodity prices and hence a surge in inflation. Furthermore, the crisis caused by the conflict in Ukraine has added to geopolitical tensions and macroeconomic volatility. In the latest RGS report the formulation of the macroeconomic projections for the national scenario has undergone some methodological updates. In particular, regarding the projection of the labour supply components, the forecast of activity rates by gender and age was carried out by adopting a cohort model, through which the generational behaviour observed in recent years is extrapolated. Compared to previous Reports, the methodology used in this Report more closely follows that developed by the EPC-WGA working group. Data from the 2022 survey, distributed by age and gender, were used as initial values for the forecast. [16] [15]

Macroeconomic assumptions - values in %		2010	2020	2030	2040	2050	2060	2070
	Participation rates [15-64]							
	- male	72.5	72.9	75.2	78.4	79.1	78.5	78.6
	- female	50.9	54.1	59.0	62.3	63.0	62.8	62.9
	- total	**61.6**	**63.5**	**67.2**	**70.6**	**71.4**	**71.0**	**71.1**
	Unemployment rates							
	- male	7.7	8.5	6.7	6.1	5.5	4.8	4.7
	- female	9.7	10.4	8.1	7.8	7.3	6.8	6.7
	- total	**8.5**	**9.3**	**7.3**	**6.8**	**6.2**	**5.7**	**5.5**
	Employment rates [15-64]							
	- male	66.8	66.6	69.9	73.3	74.5	74.4	74.6
	- female	45.9	48.4	53.9	57.0	58.0	58.1	58.1
	- total	**56.3**	**57.5**	**62.0**	**65.4**	**66.6**	**66.6**	**66.8**
	Employment(1)							
	- male		-0.2	0.4	-0.4	-0.6	-0.3	-0.4
	- female		0.3	0.9	-0.5	-0.8	-0.4	-0.4
	- total		**0.0**	**0.6**	**-0.4**	**-0.7**	**-0.3**	**-0.4**
	Productivity(1)		-0.9	1.3	1.2	1.5	1.4	1.5
	Real GDP(1)		-0.9	1.9	0.8	0.8	1.1	1.1

(1) Average annual percentage change in the preceding decade.

Table 4 Macroeconomic assumptions - National baseline scenario (RGS report of 2022) [16]

3.2.2 EPC-WGA baseline scenario

The EPC-WGA baseline scenario includes the demographic and macroeconomic assumptions agreed by the Working Group on Ageing and endorsed by the European Council's Economic Policy Committee as the background framework for the "Ageing Report". The demographic framework of the EPC-WGA baseline scenario includes the population forecast produced by Eurostat (EUROPOP2023). EUROPOP2023 applies a "partial convergence" approach, meaning that the country-specific key demographic determinants converge in the very long term towards common values. The advantage of setting the convergence point in the future is that recent trends in specific countries can be fully taken into account from the outset, while assuming that the demographic factors of the Member States will converge over time. These demographic determinants are: the fertility rate, the mortality rate and net migration derived from converging emigration rates and per capita immigration levels. The projection methodology assumes that fertility and mortality rates converge to those of the "best performing" Member States. As a result, fertility- and life expectancy rates would rise in almost all Member States between 2022 and 2070, increasing faster in the countries with the lowest levels. Net migration is estimated using separate immigration and migration flows based on: past trends, the latest empirical evidence, long-term partial convergence and consistency of intra-EU flows. The population projections produced by EUROPOP2023 apply 2022 as base year. [17]

	2022	2030	2040	2050	2060	2070	peak value	peak year	change 2022-2070
Population (thousand)	59,044	58,761	58,497	57,432	55,250	53,259	59,044	2022	-5,785
Population growth rate	-0.2%	0.0%	-0.1%	-0.3%	-0.4%	-0.3%	0.0%	2023	-0.1%
Old-age dependency ratio (pop 65+ / pop 20-64)	40.8	48.0	60.8	66.0	64.7	65.5	66.0	2050	24.7
Old-age dependency ratio (pop 75+ / pop 20-74)	17.4	19.5	24.8	32.5	33.2	31.6	33.9	2055	14.2
Ageing of the aged (pop 80+ / pop 65+)	32.0	31.9	32.1	40.7	45.9	43.1	46.0	2059	11.1
Men - Life expectancy at birth	81.1	82.4	83.7	85.0	86.1	87.1	87.1	2070	6.0
Women - Life expectancy at birth	85.5	86.8	87.9	89.0	90.1	91.0	91.0	2070	5.5
Men - Life expectancy at 65	19.5	20.5	21.4	22.3	23.2	24.0	24.0	2070	4.5
Women - Life expectancy at 65	22.7	23.7	24.7	25.5	26.4	27.2	27.2	2070	4.5
Men - Survivor rate at 65+	90.0	91.2	92.4	93.4	94.3	95.0	95.0	2070	5.0
Women - Survivor rate at 65+	94.3	94.9	95.6	96.2	96.7	97.1	97.1	2070	2.8
Men - Survivor rate at 80+	63.4	67.9	71.9	75.4	78.5	81.3	81.3	2070	17.9
Women - Survivor rate at 80+	77.5	80.5	83.2	85.6	87.7	89.4	89.4	2070	12.0
Net migration (thousand)	348.5	270.2	270.8	239.8	233.8	240.1	348.5	2022	-108.3
Net migration (% population previous year)	0.6%	0.5%	0.5%	0.4%	0.4%	0.4%	0.6%	2022	-0.1%

Population figures refer to average annual values.
Source: Eurostat, European Commission.

Table 5 Demographic assumptions- Baseline EPC-WGA scenario [18]

As regards the macroeconomic framework variables, the EPC-WGA baseline scenario incorporates the assumptions of the 2024 DEF until 2027. In the subsequent period, a gradual convergence towards the scenario assumptions defined for the 2024 Ageing Report is assumed. In particular, the rates of change of hours worked per person employed are transposed, while for activity rates and the number of employed persons, a convergence - starting from 2027 over the next 20 years - to the structural levels estimated with the Cohort Simulation Model (CSM) in the Ageing Report 2024 is assumed. [15]

	2022	2030	2040	2050	2060	2070	peak value	peak year	change 2022-2070
Labour force participation rate 20-64	70.4	71.8	73.8	75.3	75.8	76.3	76.3	2070	5.8
Employment rate of workers aged 20-64	64.8	65.3	67.9	70.4	70.9	71.3	71.3	2070	6.5
Share of workers aged 20-64 in the labour force 20-64	92.0	90.9	91.9	93.5	93.6	93.6	93.6	2059	1.5
Labour force participation rate 20-74	60.3	60.8	61.4	64.5	66.5	67.4	67.4	2070	7.1
Employment rate of workers aged 20-74	55.6	55.5	56.7	60.4	62.4	63.3	63.3	2070	7.8
Share of workers aged 20-74 in the labour force 20-74	92.2	91.1	92.3	93.7	93.9	94.0	94.0	2070	1.8
Labour force participation rate 55-64	57.9	64.5	67.5	70.3	74.2	76.3	76.3	2070	18.4
Employment rate of workers aged 55-64	55.1	61.0	64.3	67.5	71.2	73.3	73.3	2070	18.2
Share of workers aged 55-64 in the labour force 55-64	95.1	94.5	95.1	96.0	96.0	96.0	96.0	2070	0.9
Labour force participation rate 65-74	9.4	14.7	18.5	21.5	27.0	33.0	33.0	2070	23.7
Employment rate of workers aged 65-74	9.1	14.1	17.9	21.0	26.3	32.3	32.3	2070	23.2
Share of workers aged 65-74 in the labour force 65-74	97.0	96.3	96.9	97.6	97.6	97.7	97.7	2070	0.7
Median age of the labour force	44.0	45.0	44.0	44.0	46.0	46.0	46.0	2058	2.0

Source: European Commission.

Table 6 Macroeconomic assumptions - EPC-WGA scenario [18]

3.3 Model structure

Following the formulation of the appropriate reference macroeconomic and demographic scenarios it is now possible to construct the model with the aim of forecasting public pension expenditure in relation to GDP. The RGS Pension Model is designed to accurately reflect the main features of the legal-institutional framework and take into account all pension reforms implemented in the past two decades. At the same time, the model has a methodological solution that ensures consistency with demographic and macroeconomic scenario assumptions.

The model is composed of four interrelated modules (Figure 1):

- The demographic module utilizes the traditional cohort component method. This approach projects the population by age and sex based on probabilities of death, total fertility rates, and net migration flows.
- The labour market module primarily relies on projecting the labour force by age, gender, and education level, with corresponding unemployment rates applied. This projection integrates the effects of the working-age population and the cohort evolution of participation rates. The latter is obtained extrapolating the cohort trend in the propensity to enter the labour market on a permanent basis, estimated on the labour force database. Unemployment rates, segmented by age and gender, are expected to change over time, converging towards an average target value while considering the evolution of the working-age population. Total hours worked are calculated based on the proportion of part-time and full-time workers and their respective average hours worked.
- The productivity module makes use of a Cobb Douglas production function. Its projections is determined by the sum of two components: an exogenous assumption on the growth rate of total productivity factors, which is kept constant at its long-term level after an initial adjustment, and the additional contribution due to changes in the ratio of capital stock to employment (capital deepening).

- The pension module adopts a multistate approach involving a large number of relevant variables for the pension rules to be applied. Such variables are divided into two groups: state (Table 7) and monetary variables.

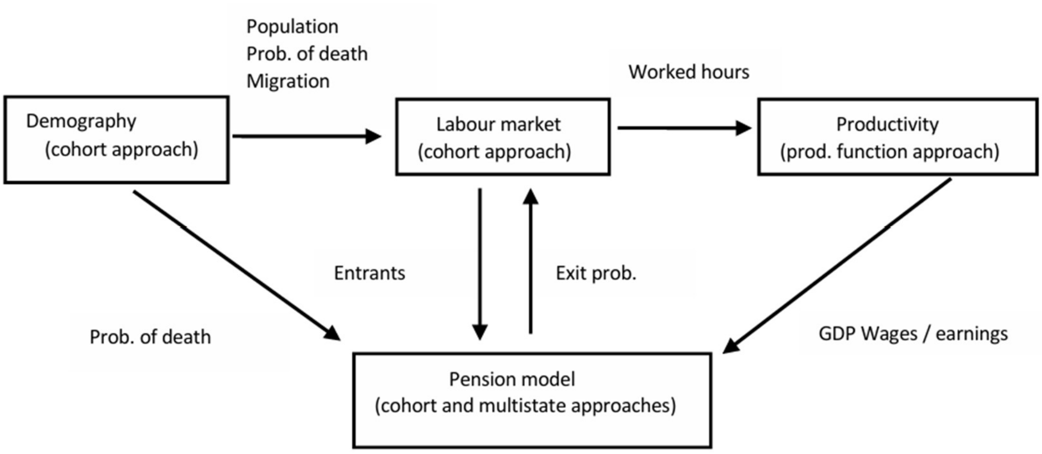

Figure 1 Interrelations between the modules of the RGS pension model [18]

State variables	Specifications
Fund (or group of workers)	13 in the private sector and 5 in public sector
Sex	Male, female
Age	[15-74]
Typology of contributor	Contributor, dormant, pensioner-contributor
Contribution years	[0-49] before retirement; [1-20] after retirement
Regime	Earnings-related, contribution-based, mixed
Typology of pension	Disability (2 types), old age, early retirement

Table 7 State variables, variables that identify distinct positions within the system [18]

At any moment, using the following equation it is possible to identify members of the pension system in terms of their belonging to one of the possible combinations of the state variable specifications:

$$\underbrace{\boldsymbol{a}_{t,s,x,f}}_{members} = \underbrace{\boldsymbol{a}_{t\text{-}1,s,x\text{-}1,f}}_{members} \underbrace{\varphi_{t-1,s,x\text{-}1,\,f}}_{\substack{probability\\ of\ surviving}} \times \underbrace{\boldsymbol{T}_{t\text{-}1,s,x\text{-}1,f}}_{\substack{transition\\ matrix}} + \underbrace{\boldsymbol{e}_{t,s,x,\,f}}_{entrants} \qquad \forall s,\ f, 15 \leq x \leq \omega$$

where, for each sex *s*, age *x*, and fund (or specific group of workers) *f*, *a* indicates the row vector of the insured distributed by different states at the end of the year *t*, φ is the probability of surviving, *e* indicates the row vector of entrants to the pension system in the year *t*, and *T* is a matrix of transition probabilities that allows to calculate the changes in the state of members already insured at the end of the year *t-1* and still alive at the end of the year *t*. The general element $t_{i,j}$ of the transition matrix expresses the probability that a member belonging to state *i* at the end of the year *t-1* will transit to state *j* at the end of the year *t*. New entrants, that is those insured for the first time in the pension system, are converted into new contributors. The numbers of entrants by age and sex are assigned to each fund, or specific group of workers, on the basis of specific distributions of probability. Mean values of monetary variables are associated with each of the possible combinations of the state variable specifications and supplemented with variation coefficients and distribution functions. Furthermore, it is required to calculate the number of indirect pensions, i.e. new survivors' pensions, by applying the probabilities of death and the likelihood of leaving a surviving spouse (or dependent children) to pensioners or contributors who have already qualified for retirement. A permutation matrix is then used to assign an age to the surviving spouse based on the age of the deceased. These new survivors' pensions are subsequently added to the existing pensions from the previous year that are still being paid out. [18]

3.3.1 Methodological specifications

By observing and simplifying past RGS reports, specifically that of 1998, it is possible to have a deeper mathematical and stochastic understanding of the pension module's workings. As already established, the model is aimed at forecasting public pension expenditure (*S*) as a ratio of GDP.

At a time *t+1*, total pension expenditure (*S*) can be expressed followingly:

$$S = \sum_{f} \sum_{s} \left(S_{fsc} + S_{fsr} \right) \tag{1}$$

where *f* identifies the pension fund, *c* the direct pensions, *r* the indirect pensions and *s* the gender. Therefore, *S* is calculated as the sum, with respect to each fund and sex, of indirect and direct pensions, each categorized according to the respective fund and sex.

Expenditure on direct pensions, broken down by fund and sex, can be determined as the sum, with respect to all possible age groups, of the products of the number of pensioners and the corresponding average pension amount:

$$S_{fsc} = \sum_{i=1}^{n} p_{fsc}^{i} \times b_{s}^{i} \times m_{fsc}^{i} \qquad (2)$$

where p_{fsc}^{i} indicates the percentage incidence of the number of pensioners of the i-th age, belonging to fund *f* and sex *s*, on the total resident population. Subsequently, b_{s}^{i} is the resident population of sex *s* and age *i*, while m_{fsc}^{i} is the average amount of pensions of fund *f*, sex *s* and age *i*. The latter can be obtained by computing the weighted average between: the average pension amounts in the previous time period updated to current regulations and the average amount of pensions taking effect during the year and surviving at time t+1.

The percentage incidence of the number of pensioners p_{fsc}^{i} is determined by the following formula:

$$p_{fsc}^{i} = z_{fsc}^{i} \times y_{fs}^{i} \qquad (3)$$

where z_{fsc}^{i} is the conditional probability that an individual of sex *s*, age *i* and fund *f* receives a direct pension *c*, while y_{fs}^{i} is the conditional probability than an individual of sex *s* and age *i* belongs to a fund *f*. Therefore, the generic element p^{i} can be interpreted as the probability that a population unit, of i-th age and sex *s*, is a direct pensioner of fund *f* at time *t+1*.

Breaking down the two elements of the previous formula we obtain that:

$$y_{fs}^{i} = \bar{y}_{fs}^{i} \times \left(1 - \delta_{s}^{i} - \bar{a}_{s}^{i}\right) \qquad (4)$$

where $\bar{y}_{fs}^{i}$ indicates the distribution of the population, already belonging to the pension system, of age *i* and sex *s* between the different funds *f*. δ_{s}^{i} is the schooling rate by sex and age, while $\bar{a}_{s}^{i}$ is the “residual” population not allocated nor enrolled in a regular study course.

The second element of (3) can be defined as:

$$z_{fsc}^{i} = z_{fsc}^{i-1} + \left(1 - z_{fsc}^{i-1}\right) \times h_{fsc}^{i} \tag{5}$$

where z_{fsc}^{i-1} is the conditional probability that an individual of sex *s*, age *i-1* and fund *f* received a direct pension *c* in the previous year. The second addend represents the new entrants: individuals of a certain sex, age and fund who did not receive a direct pension the previous year $\left(1 - z_{fsc}^{i-1}\right)$ by the retirement rate h_{fsc}^{i}. The retirement rate expresses the probability that an individual who is not retired, belongs to a fund *f* and is of sex *s*, accesses retirement on the i-th age:

$$h_{fsc}^{i} = \frac{retirements\ during\ the\ year\ between\ t\ and\ t+1}{subsequent\ retirments\ after\ t+1}\ . \tag{6}$$

The pensions taking effect during the year, needed in (6), are dynamically calculated for each sector, age and gender, on the basis of retirement flows by age, gender and contribution seniority obtained with multi-state models developed by RGS for the main pension schemes. These models adopt forecasting techniques based on Markovian, finite, discrete and non-homogeneous processes. The process is finite in that the number of possible positions is limited; it is discrete in that it is assumed that the change of state occurs at regular one-year intervals; it is non-homogeneous because the probability of moving from one state to another is generally time-dependent. The Markovian process operates on the following states: the pension system (retribution-based, contribution-based and mixed), the insurance status, (contributor, silent, pensioner contributor, pensioner), contribution seniority (annual classes from 0 to 40) and pension type (pension of invalidity and old age).

Similar to what was explained for direct pensions , expenditure on indirect pensions can be determined as follows:

$$S_{fsc} = \sum_{i=1}^{n} p_{fsr}^{i} \times b_{s}^{i} \times m_{fsr}^{i}\ . \tag{7}$$

What changes significantly is the method used to estimate p_{fsr}^{i} which now has to take into account of the probability of death and the likelihood leaving a surviving spouse (or dependent children) to pensioneers.

Pension expenditure, determined according to the equations outlined above, has a “trend” interpretation: it is obtained by multiplying the stock of pensions in force by the corresponding pension amounts expressed on an annual basis. GDP, on the other hand, expresses the amount of resources produced by the country in the course of a year and, therefore, should be compared with annual pension expenditure. This quantity differs from trend expenditure since it is affected by the turnover between "outgoing" and "incoming" pensions and changes of average pension amounts during the year. If the percentage difference between the two magnitudes is assumed stable, the dynamical annual pension expenditure can be approximated by the trend expenditure. This allows the following equivalence to be established:

$$\frac{S_\tau}{GDP_\tau} = \frac{S_{\tau_0}}{GDP_{\tau_0}} \frac{I^S_{\tau_0/\tau}}{I^{GDP}_{\tau_0/\tau}} = \frac{S_{t_0}}{GDP_{t_0}} \frac{I^S_{t_0/t}}{I^{GDP}_{t_0/t}} \tag{8}$$

where τ indicates the interval *t/t+1* and τ_0 a generic interval τ_0/τ_0+1. $I_{\tau 0/\tau}$ and $I_{t0/t}$ are the variation factors of the variable indicated in the superscript over the interval of time interval indicated in the subscript. In conclusion, pension expenditure as a ratio of GDP is obtained. [19]

Chapter 4

Medium- to long-term dynamic microsimulation models

4.1 The Treasury Dynamic Microsimulation Model

Microsimulation models employ simulation techniques that focus on micro-level units as the primary subjects of analysis to examine the impacts of social and economic policies. In recent years, the widespread availability and accessibility of computing power have significantly expanded the use of these techniques for economic analysis and decision-making support. Additionally, the growing availability of extensive and detailed micro datasets has further enhanced the effectiveness of microsimulation models in evaluating income distribution and social policies. Dynamic microsimulation models (DMMs) incorporate inter-temporal events such as aging, marriage, fertility, education, occupational status, consumption, saving, and retirement decisions. These models replicate individual life-cycle trajectories in alignment with recorded socio-demographic phenomena. One of the key advantages of DMMs is their use of micro units, enabling detailed analysis of complex interactions between different population groups. Microsimulation models are highly flexible, allowing for easy adjustments to the underlying assumptions of individual micro processes whereas dynamic microsimulation models excel in examining inter-temporal issues and making long-term projections. The main uses of DMMs are: projections, evaluations of public policy, designing of policy reforms, studies of inter-temporal processes of behaviour and investigating inequality and redistribution. [20]

This chapter focuses on the characteristics and functions of the updated version of the Treasury Dynamic Microsimulation Model (TDYMM 3.0) owned by the Department of the Treasury of the Italian Ministry of Economy and Finance and developed in collaboration with Sogei. As one of the few dynamic microsimulation models currently in use in Italy, it was developed through three research projects funded by the European Commission from 2009 to 2021. The initial release of T-DYMM was heavily influenced by MIDAS-IT, a DMM created by ISAE (*Istituto di Studi e Analisi Economica*, Institute of Economic Studies and Analyses), which itself was based on MIDAS Belgium. The second and third versions of T-DYMM have significantly expanded the model's structure and dataset, and transitioned it to the current platform, Liam 2.0.1. T-DYMM is designed to offer long-term analyses of the Italian social security system, emphasizing the adequacy of pensions and social protection, as well as their distributional impacts. [21]

4.2 Data

A crucial element of any dynamic microsimulation model is its baseline dataset. Typically, this dataset is derived from a primary source, consisting of individual records from surveys or administrative data. This primary data is then supplemented with information from additional sources through imputation or matching techniques. The use of multiple data sources aims to address information gaps in the primary dataset or to incorporate external data.

The T-DYMM dataset is primarily constructed by integrating data from the Italian component of the European Union Statistics on Income and Living Conditions (IT-SILC) survey, provided by ISTAT, with administrative data from INPS. This integration is achieved using individual tax codes, which are then anonymized. The resulting merged dataset is called "AD-SILC". AD-SILC is an unbalanced panel dataset that currently includes information from all IT-SILC waves from 2004 to 2017, along with data from the INPS archives. From IT-SILC, it gathers longitudinal data on socio-economic characteristics for 254,212 individuals. From INPS, it collects longitudinal data on pensions (disability, old-age, survivor, etc.) and work history (occupational status, income evolution, contribution accrual, etc.), totalling 6,182,926 observations spanning the period from 1922 to 2018.

In addition to the IT-SILC and INPS data, the current version of AD-SILC (so-called AD-SILC 3.0) contains three main innovations compared to its predecessors:

- the addition of 5 SILC waves (2013-2017, a 25% increase in the sample size compared to AD-SILC 2.0);
- the merge of information from Tax returns and Cadastre (collected by the Finance Department of the Italian Ministry of Economy and Finance) for the corresponding 2010, 2012, 2014 and 2016 SILC waves;
- the inclusion, by means of a statistical matching procedure, of information from the Survey on Household Income and Wealth (SHIW) conducted by the Bank of Italy.

These last two innovations in data sources enable the creation of a comprehensive dataset on household wealth, marking a significant addition to the latest T-DYMM release. House wealth is derived from administrative data provided by the Cadastre and Tax returns, while financial wealth and liabilities information is sourced from SHIW. A collaborative effort between the Treasury Department and the Finance Department has been established, paving the way for potentially stronger dataset linkages in the future.

AD-SILC can be employed for a number of uses:

- to analyse historical dynamics;
- to estimate transition probabilities and determinants of labour income to be included in T-DYMM;
- to derive the starting sample for the simulations.

The starting sample for the simulations, mentioned in the third point, is derived from the latest IT-SILC wave, which is linked with all the administrative data from INPS and includes imputed financial wealth amounts from SHIW. Before running the simulations, the starting sample needs to be weight-calibrated to improve its representativeness across various dimensions. Once calibrated, the sample is expanded by multiplying individuals by the calibrated weights (see 4.4 Methodological specifications). This step is crucial to address representativeness issues that arise when using alignment methods in dynamic microsimulation. Next, 100 samples of 100,000 households each are drawn with replacement. The best-fitting sample, in terms of alignment with administrative data, is then selected. This process results in a starting sample of 238,431 individuals, referred to as T-DYMM's base year sample. [21] [22] [23]

4.2.1 Exogenous data

Exogenous data are used to align various patterns within simulations thereby incorporating additional information not available in the estimation data. Alignment, a common technique in microsimulation modelling, ensures that simulated totals match exogenously specified targets or aggregate projections. For dimensions that cannot be generated within the model, such as fertility and mortality rates, GDP growth, and inflation, alignment is essential. In institutional models like T-DYMM, it may be preferable to align certain macroeconomic dynamics with third-party projections, allowing the model to concentrate on individual or household distributions. Additionally, alignments can be used to simulate sensitivity scenarios. [21] [22]

Module	Process	Source
Demographic module	Fertility, mortality, immigration and emigration flows	ISTAT (historical data) and Eurostat - Europop 2019 projections
	Education, age of exit from original household, informal and formal marriages, divorces	ISTAT and OECD (for education achievements of immigrants)
Labour Market module	Employment rate, inflation growth, GDP growth, productivity growth	ISTAT (historical data) and European Commission 2022 Spring Forecasts and Working Group on Ageing Populations and Sustainability (AWG) assumptions
	Take-up rate of unemployment benefits	INPS
	Quota of permanent public employees	ISTAT
Pension module	Number of disability allowances and incapacity pensions	INPS
	Enrolment in private pension plans	Italian Supervisory Authority on Pension funds (COVIP)
Wealth module	Households that pay rent	Department of Finance
	Returns on financial and housing assets	European Commission 2022 Spring Forecasts and AWG assumptions, Italian Housing Observatory (*Osservatorio del Mercato Immobiliare*, OMI) and Standard & Poor's (S&P) 500
	Houses sold and bought, average propensity to consume	ISTAT
Tax-Benefit module	Beneficiaries of selected tax expenditures and substitute tax regimes	Department of Finance
	Take-up rates of specific social assistance measures	INPS

Table 8 Main processes in T-DYMM by use of alignment procedures, arranged according to module and source. [23]

4.3 Model structure

In the following version of the model, the starting sample is set in 2015 and simulations run on an annual basis from 2016 until 2070 (the projection horizon of the 2021 Ageing Report). The modular organization is logical but does not necessarily reflect the sequence of processes the model addresses.

The baseline version of T-DYMM currently presents the following structure:

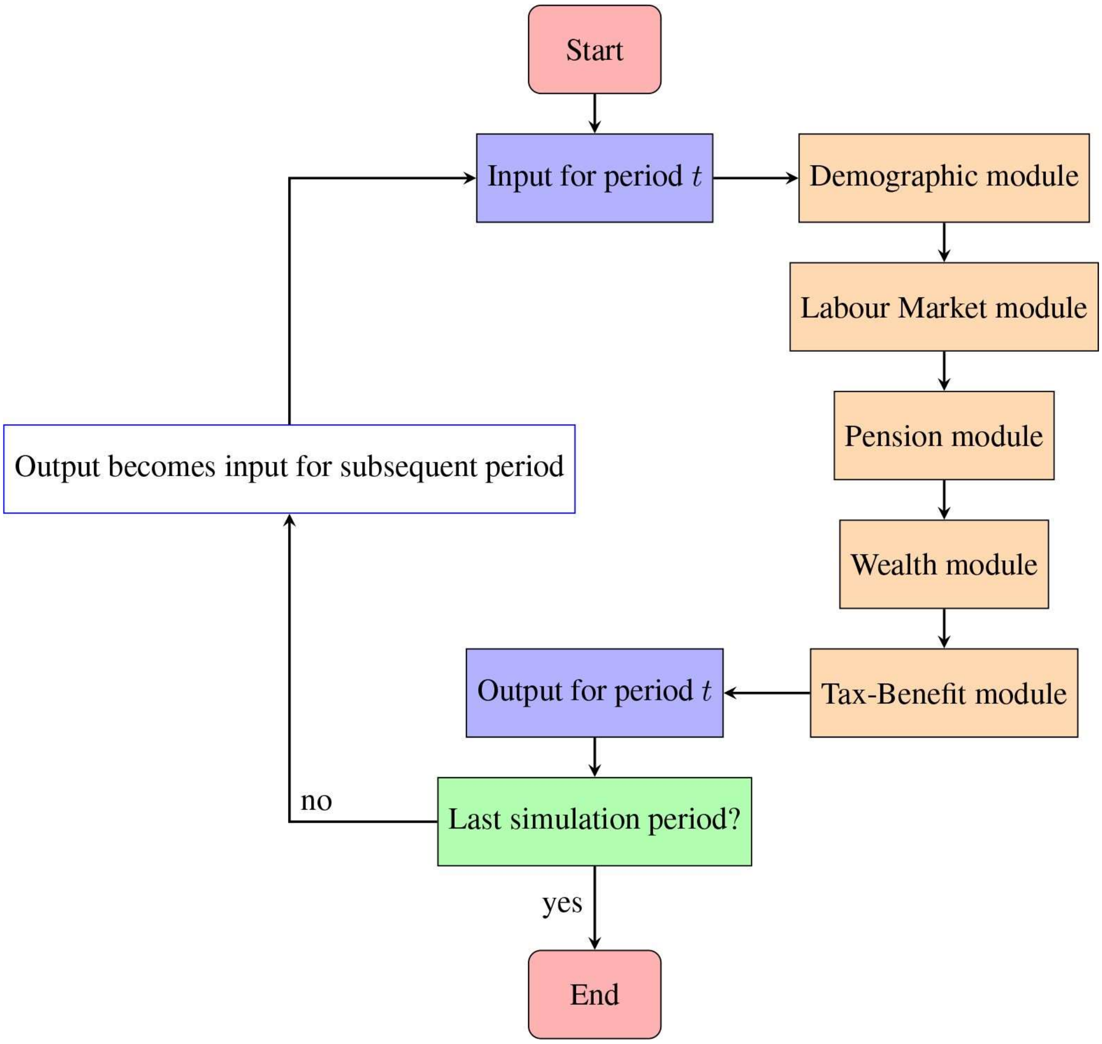

Figure 2 Modular structure of T-DYMM [23]

It is observable that the model is divided into 5 different modules: the demographic module, the labour market module, the pension module, the wealth module and the tax-benefit module. The *input for period t* (and consequently the *output for period t*) is determined by the dimension taken into consideration by the starting sample derived from AD-SILC. This section will focus in particular on the structure of the pension module (Figure 3) which largely draws from the experience of the previous releases of T-DYMM.

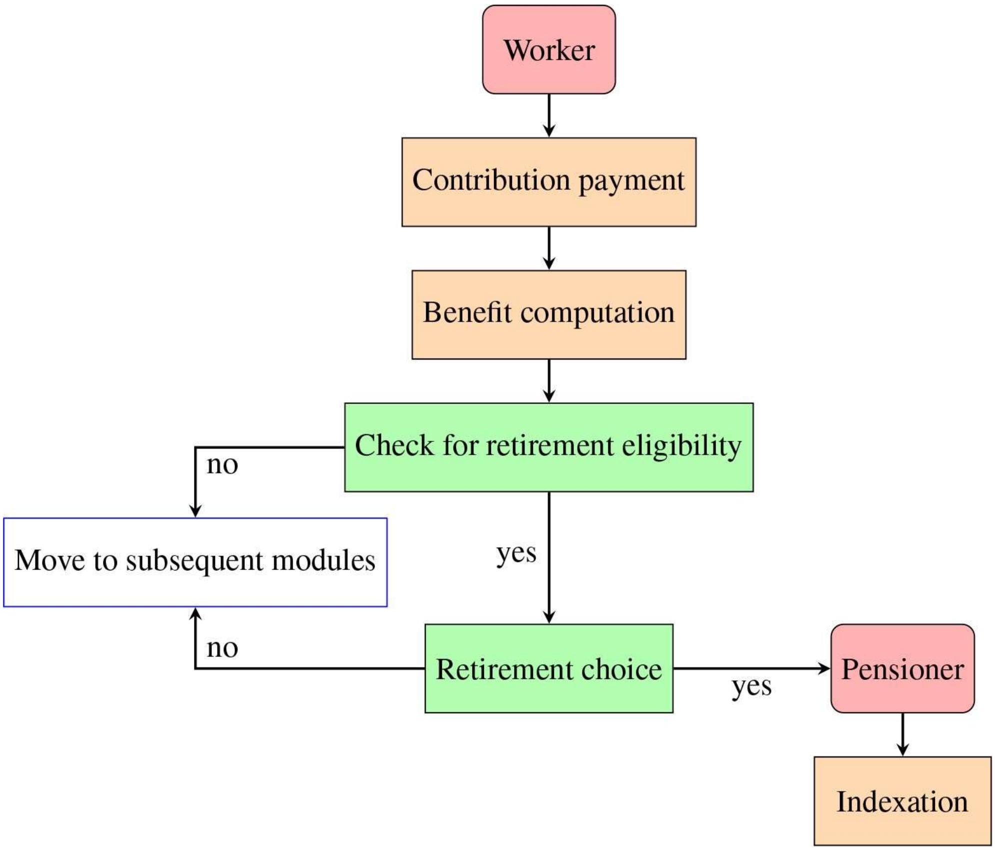

Figure 3 Structure of the Pension module, work-related public pensions (1st Pillar) [23]

The pension module's first input is the worker which contributes to the public pension system on a mandatory base, with contribution rates set accordingly to the employment category assigned in the Labour Market module. Each year, potential pension benefits are calculated based on two different pension regimes. Current contributors to the pension system fall into two main categories:

1. Pure NDC (Notional Defined Contribution):

- for workers with no seniority before 1996,
- benefits are entirely calculated according to NDC rules.[2]

---

[2] As mentioned in Chapter 1, NDC computation rules were first introduced by the Dini Reform in 1995 and then extended to all workers by the Fornero Reform in 2011.

2. Mixed:

- Mixed 1995: For workers with less than 18 years of seniority in 1995. Benefits are calculated pro rata according to NDC rules for all years of seniority after 1995.
- Mixed 2011: For workers with at least 18 years of seniority in 1995. Benefits are calculated pro rata according to NDC rules for all years of seniority after 2011.

Once potential benefits are computed, individuals are assessed for retirement eligibility (Table 9).

Criteria	Regime	Requirements	2021
Old age 1	NDC	age	64 years
		seniority	20 years
		amount	2.8**assegno sociale*
Old age 2	NDC, mixed	age	67 years
	NDC, mixed	seniority	20 years
	NDC	amount	1.5**assegno sociale*
Old age 3	NDC	age	71 years
		seniority	5 years
Seniority	NDC, mixed	seniority, males	42 years, 6 months
		seniority, females	41 years, 6 months
Seniority - young workers	mixed	seniority	41 years, 12 months accrued before turning 19
Seniority - *Quota 100*	mixed	age	>62 years
		seniority	>38 years

Note: The *assegno sociale* is the social allowance for the elderly. Since 2018, age requirements are aligned to Old age 2. Concerning Old age 2 seniority requirement, 15 years suffice for workers with at least 15 years of seniority as of Dec 31st 1992. For 2022, Seniority - *Quota 102* has replaced *Quota 100* and the age requirement has risen to 64.

Table 9 Eligibility requirements for retirement as simulated in T-DYMM [21]

Subsequently, it is necessary to determine the amount of workers who choose to access retirement. In the previous version of T-DYMM it was assumed that individuals typically retired as soon as they were eligible. However, with the introduction of new regulations, there is now a financial incentive to delay retirement. By assuming that all workers retire immediately, it is implied that everyone prioritizes early retirement over higher pension benefits. This assumption may not accurately reflect the diverse preferences of individuals. The latest version of T-DYMM attempts to address this by considering individual-specific factors: workers who meet eligibility requirements for retirement undergo a decision process determined by a choice function based on an option value model proposed by Stock and Wise (1990).

If workers meet the requirements for retirement, they will decide between either ceasing or continuing to work, they do so by choosing the optimal retirement age that maximises the expected utility over the life cycle composed of work income and retirement income separately. For each year in the discrete age interval taken as a reference, it is first necessary to estimate the expected value of both income components. The choice of the age at which to retire is made when individuals are 60 assuming they were all born on 1 January. This means that the income from employment is unknown in the first and subsequent years of the age interval in which the retirement decision is planned (and the same applies to retirement income). The value function is then defined as follows:

$$V_t(R) = \sum_{s=t}^{r-1} \left(\frac{1}{1-p}\right)^{s-t} \cdot p(s \mid t) \cdot U_y((Y_s)^{\gamma}) + \sum_{s=r}^{S} \left(\frac{1}{1-p}\right)^{s-t} \cdot p(s \mid t) \cdot U_b(kB_s(R)^{\gamma})$$

where t is equal to 1 (60 years in our age interval); s varies over the age range (extreme values included); p is the rate applied to discount future income flows; $p(s|t)$ represents the probability of survival in the s-th year; γ is a parameter that reflects individual risk aversion; $B_s(R)$ are the pension benefits received; S is the year in which the probability of dying is 1. In this formula, for each year between the present and the "maximum retirement age" (the age requirement for the "Old Age 3" criterion, presently set at 71), utility to access pension in the current period is compared with the utility obtained by postponing retirement in yearly steps. Future earnings are projected based on the most recent salary, adjusted for inflation and productivity growth. Individuals tend to opt for working the entire year because, if their employment ends, they will still be eligible for retirement (assuming they meet the necessary criteria), regardless of the decision they made earlier. Therefore, unemployment risk is not considered. For each year, a hypothetical retirement age and initial pension are calculated based on projected work history. Utilities are determined by a weighted (by survival probability) sum of discounted future earnings and pensions, net of taxes and contributions. Retirement is chosen when the utility of immediate retirement exceeds the utility of delaying retirement.

Exogenous parameters influencing the model include discount rates (labour productivity and inflation), risk aversion, and leisure preferences. Upon retirement, pensions are paid out and adjusted for inflation based on relevant laws, with full indexation limited to lower-tier pensions. In addition to seniority and old-age pensions, the Pension module incorporates minimum pension guarantees for workers in the "Mixed" category, disability pensions, and survivor benefits. [24] [23] [21]

4.4 Methodological specifications

The starting sample mentioned previously (4.2 Data) must accurately represent the population taken as reference. It is the foundation for most models that aim to accurately represent simulated reality. T-DYMM 3.0 uses an established technique for calibrating sample units in order to run simulations on a dataset that realistically represents the many dimensions of interest. The total frequencies of different subgroups of samples are calibrated (at the individual level) using the aggregate values made available by the Italian Department of Finance and ISTAT. The recalibration of the weights is obtained by minimising the following Lagrangian function with respect to the recalibrated weights:

$$L = \frac{1}{2}\sum_{j=1}^{k} \frac{\left(rw_j - ow_j\right)^2}{ow_j} + \sum_{k=1}^{m} \lambda_k \left[t_k - \sum_{j=1}^{k} rw_j\, x_j\right]$$

where *ow* is the original weight; $(rw_j\text{-}ow_j)/ow_j$ is the chi-square distance function for the j-th individual; λ_k is the k-th Lagrange multiplier; t_k is the k-vector of external totals; x_j is the vector of variables subject to calibration. The focus of the recalibration concerns several dimensions. To date, the following have been analysed: number of taxpayers, employees, self-employed and pensioners with positive gross income subject to personal income tax by income class and geographical area; individuals and households by gender; households by number of members and type; immigrant individuals and households by gender and birth macro-area; individuals by age group; individuals aged 15 years and over by highest level of education attained. Microsimulation models can also be used to estimate aggregate and average values (e.g. total pension expenditure), requiring the appropriate use of calibration techniques. [24]

Chapter 5

Projection results

5.1 Results of the State General Accounting Department projection model

In this subsection the results of the State General Accounting Department projection model are presented. The outcomes are obtained on the basis of the macroeconomic and demographic assumptions of the scenarios described in Chapter 3, based on the legislation currently in force. Before illustrating the results it is important to briefly mention the key measures which have helped control the ratio of pension expenditure to GDP in Italy, these include: switching to a price-only indexation system for pensions; implementing a contributory calculation system that aligns benefits with contributions and life expectancy; raising the minimum requirements for both ordinary and early retirement; periodically adjusting transformation coefficients and retirement eligibility requirements based on life expectancy.

5.1.1 National base scenario projection results

Figure 4 illustrates graphically the national baseline scenario projection results of public pension expenditure in relation to GDP. The significant rise in spending as a percentage of GDP in 2020 is largely a result of the sharp GDP decline caused by the healthcare emergency, subsequently the ratio improved during the 2021-2022 period as GDP recovered. The steep increase is also conditioned by the implementation of the measures in the social security sector aimed at favouring access to early retirement (in particular the "Quota 100"), which determine for the years 2019-2021 a substantial increase in the number of pensions relative to the number of employed workers. In the years 2023-2024, expenditure as a ratio of GDP increases reaching 15.6 per cent at the end of the two-year period, a level that is substantially maintained until 2028. From 2030 the ratio starts to increase again, reaching 17 per cent in 2040. This trend is due to the increase in the proportion of the number of pensions to the number of employed workers induced by the demographic transition, which is only partially offset by the increase in the minimum requirements to access retirement. The effect due to the increase in the number of pension treatments outweighs the effect of the containment of pension amounts exerted by the gradual application of NDC rules to the entire working life. After a three-year period of substantial stability, from 2044 the ratio of pension expenditure to GDP decreases, first gradually and then rapidly, reaching 13.9 per cent in 2070. The rapid reduction in the last phase of the projection period is determined by the generalised application of contribution-based calculation, which is accompanied by a reversal in the ratio of the number of pensions to the number of employed persons. This trend is affected by both the gradual exit of the baby-boom generation and the effects of the automatic adjustment of minimum retirement requirements to life expectancy. Figure 4 compares the national baseline scenario forecast in the report coinciding with the forecast of the DEF 2024 with the one underlying the Note of Update of the DEF 2023. The difference between the two scenarios is given by the change in the short-term macroeconomic framework in the DEF 2024 and in particular the incorporation of a higher level of nominal GDP recorded in the National Accounts for the year 2023. [15]

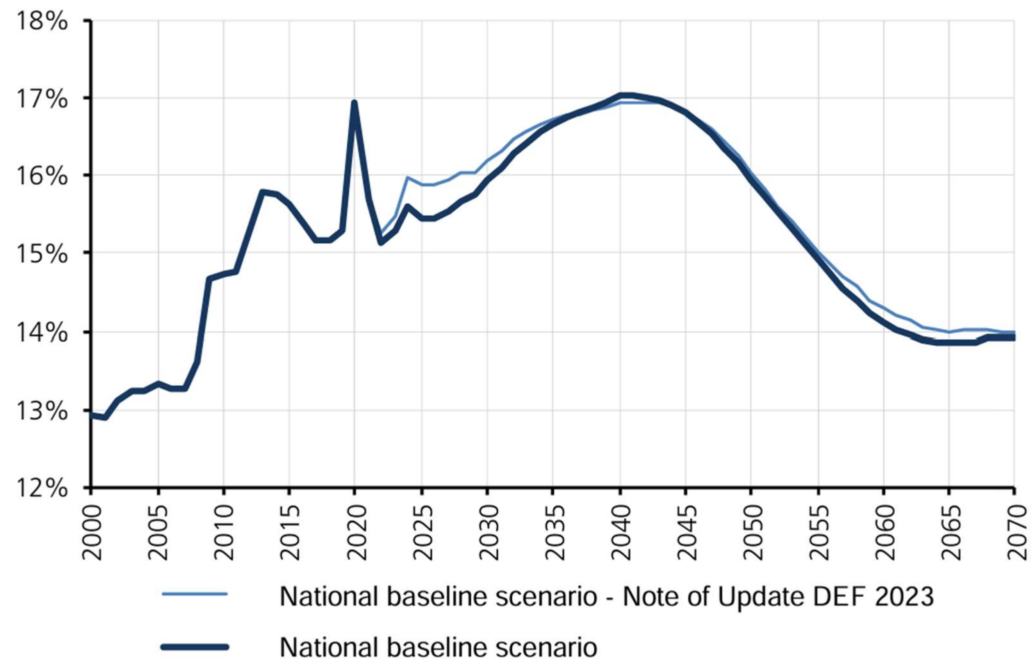

Figure 4 Public pension expenditure in relation to GDP - National baseline scenario. [15]

5.1.2 EPC-WGA baseline scenario projection results

Figure 5 illustrates graphically the EPC-WGA scenario projection results of public pension expenditure in relation to GDP. The overall trends of the projections of the EPC-WGA scenario are similar to those of the national scenario and present the same type of explanation behind them. In 2022, public pension expenditure stands at 15.6% of GDP. This ratio is expected to decrease by 1.9 percentage points from 2022 to 2070. Initially, the ratio will rise due to several factors. The primary driver is the demographic shift caused by the retirement of the baby-boom generation, which is further magnified by policies that have relaxed early retirement access. Although the introduction of NDC rules, which are gradually being implemented, lowers average pension benefits and partially offsets this increase, demographic pressures continue to outweigh the reduction in benefit levels. In the latter part of the projection period, the pension expenditure ratio is anticipated to fall rapidly. This decline is attributed to the full implementation of the NDC scheme and the stabilization, followed by a decrease in the pension-to-employee ratio. These changes are driven by the gradual retirement of the baby-boom cohorts and adjustments to eligibility requirements based on life expectancy. Figure 5 compares the latest projections with those from the 2021 Ageing Report. For the years 2019-2022, the share of public pension expenditure relative to GDP is lower than previously reported. This reduction can be attributed to a higher actual GDP and a decrease in the number of existing pensions, partly due to increased mortality among the elderly during the COVID-19 pandemic. [18]

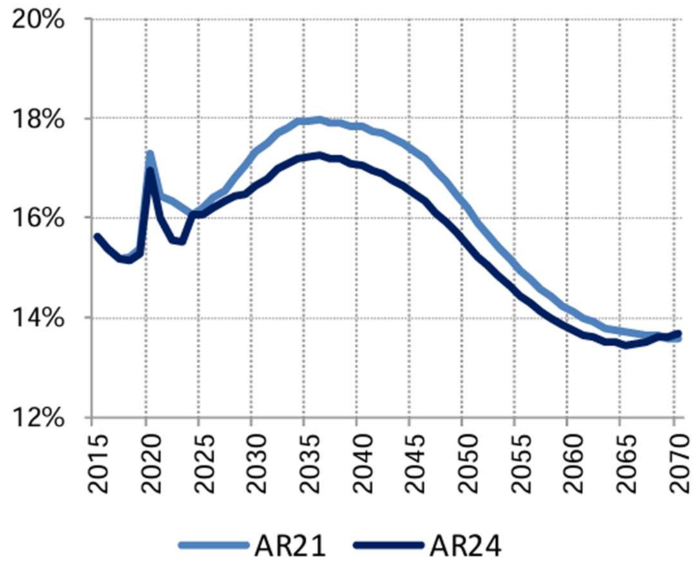

Figure 5 Public pension expenditure in relation to GDP - EPC-WGA scenario [18]

5.2 Results of the Treasury Dynamic Microsimulation Model

This subsection presents the results of T-DYMM's baseline scenario for the simulation period 2016-2070, focusing on the findings of the pension module. The demographic and macroeconomic frameworks underlying the simulations align with the European

Commission's 2022 Spring Forecasts for Italy and the baseline scenario of the 2021 Ageing Report.

Figure 6 and Figure 7 explore the coverage of the pension system for individuals over 64 years of age, focusing on four types of pensions: Old-age or seniority pensions; Inability pensions; Survivor pensions; Any of the above. It is observable that the percentage of elderly males receiving old-age or seniority pensions is projected to decrease by over 21 percentage points from 2020 to 2070. This decline is due to increasing retirement ages linked to life expectancy changes and the growing number of migrant workers who may not meet retirement criteria and thus rely on social assistance. The percentage of elderly females receiving old-age or seniority pensions is expected to increase by 2 percentage points by 2070, thanks to rising employment rates among women. A significant reduction in survivor pensions is anticipated due to fewer marriages and equalized life expectancy between genders.

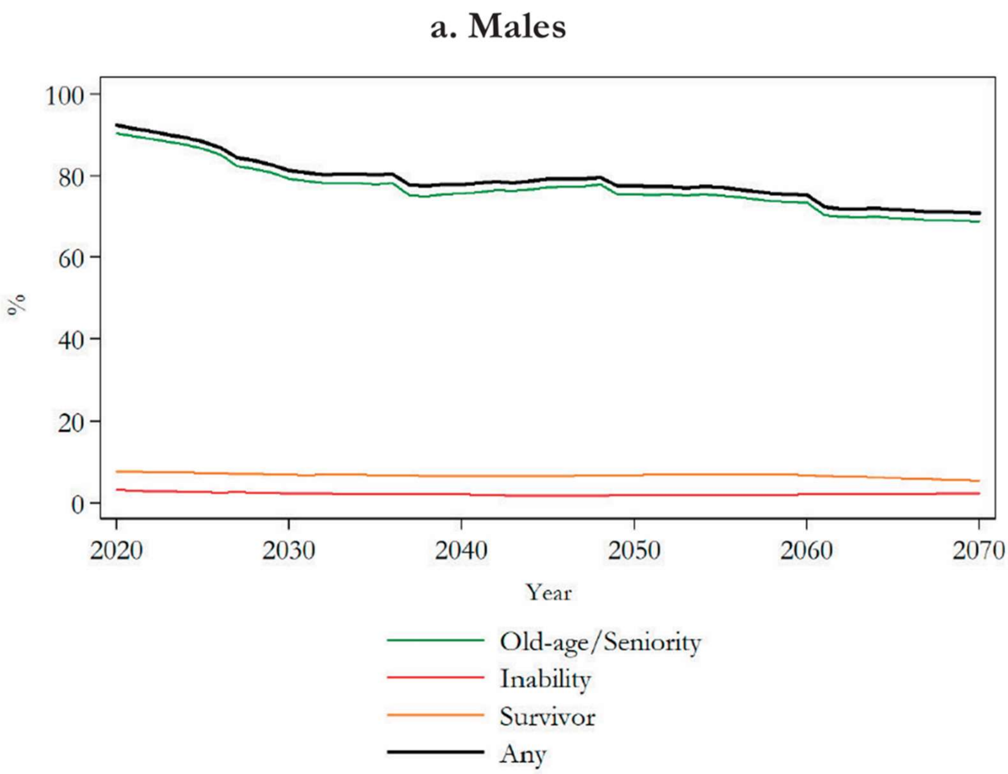

Figure 6 Coverage of the pension system for male aged 65 and over [22]

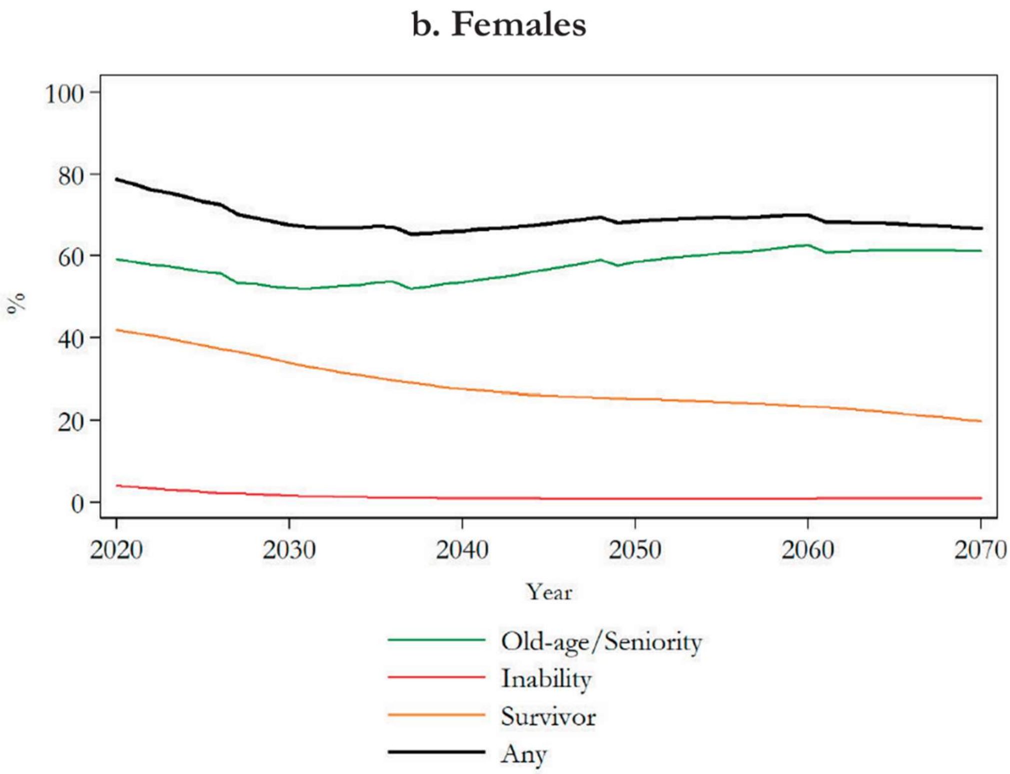

Figure 7 Coverage of the pension system for females aged 65 and over [22]

As the Italian pension system transitions from a Defined Benefit (DB) scheme to a Notional Defined Contribution (NDC) scheme, it's important to understand how this change affects newly retired individuals. Initially, most new retirees receive benefits calculated under the old DB rules. Over time, the proportion of pensions computed under the DB scheme gradually decreases. By 2070, all workers will be fully enrolled in the NDC scheme. This shift marks a significant change in the way pensions are calculated and distributed in Italy. This process is illustrated in Figure 8. Meanwhile, Figure 9 shows that, throughout the simulation period, male workers are consistently more likely to meet early retirement criteria compared to female workers. This is attributed to male workers generally having more stable and better-paying career jobs, which makes it easier for them to satisfy the requirements for early retirement.

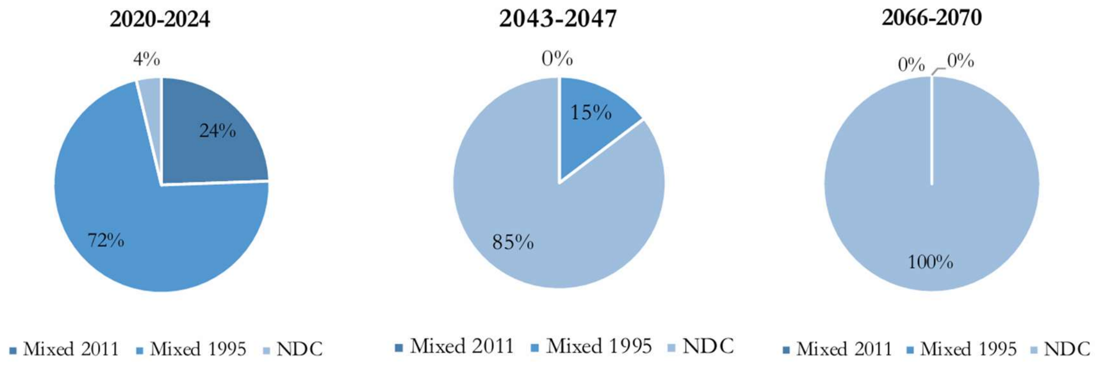

Figure 8 Newly retired pensioners by pension regime [22]

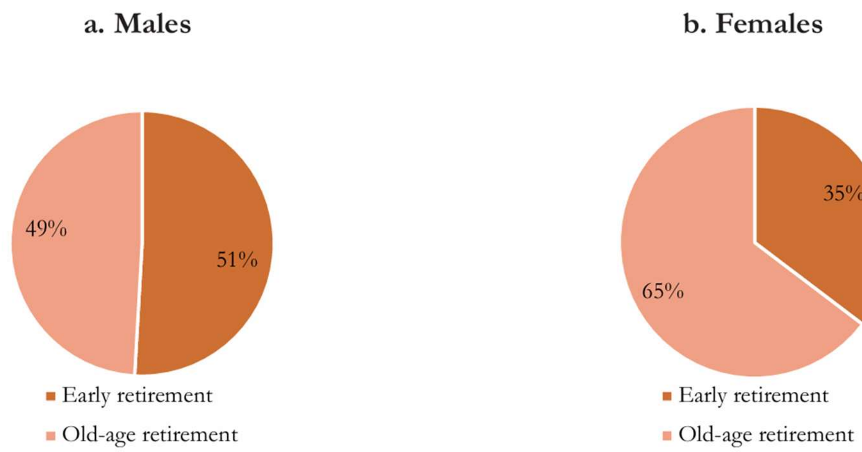

Figure 9 Newly retired pensioners by retirement criteria and gender, 2020-2070 [22]

Throughout the simulation period, the average retirement age for women is slightly higher than for men (Figure 10). This is despite the fact that the required amount of years of contribution for the "Seniority" criterion is one year lower for women than for men. As previously mentioned, women often face more challenges in meeting retirement requirements, making them nearly twice as likely as men to settle on old-age retirement. Women are projected to retire at the same age as men within the first few years of the simulated period. Subsequently, according the simulations, average retirement ages would increase by about 5 years for male workers and over 6 years for their female correspondents in the 2020-2070 period. The anticipated increase in retirement ages is expected to lead to a decrease in the average time spent in retirement, particularly for women. In fact, retirement duration is projected to decrease from over 25 years to 22 years for women and from over 21 years to less than 20 years for men between 2015 and 2070 (Figure 11).

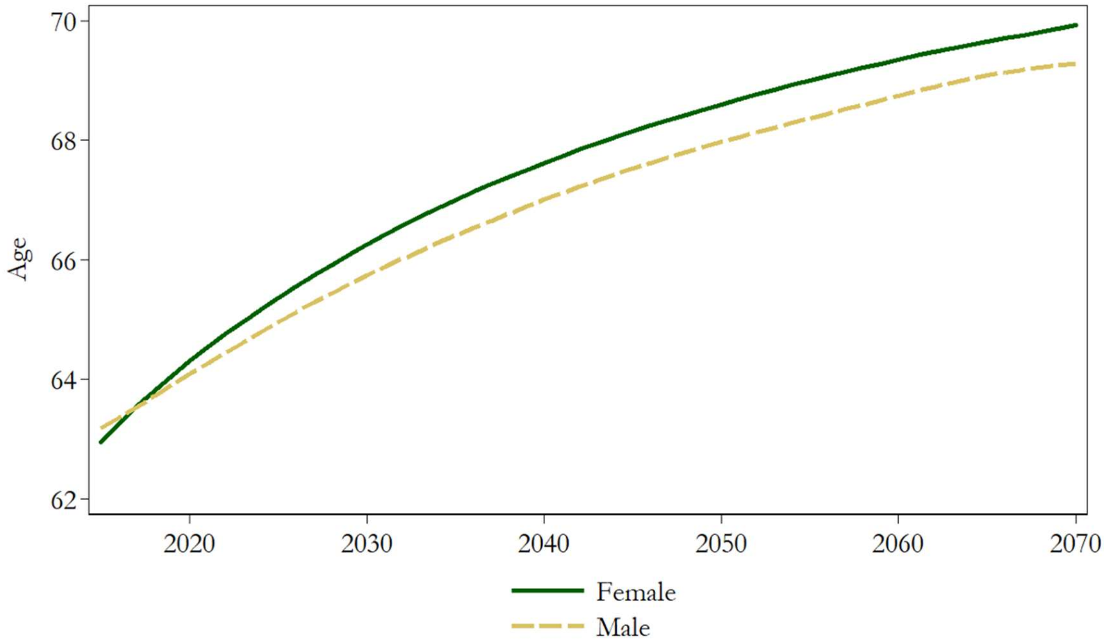

Figure 10 Average retirement age by gender [21]

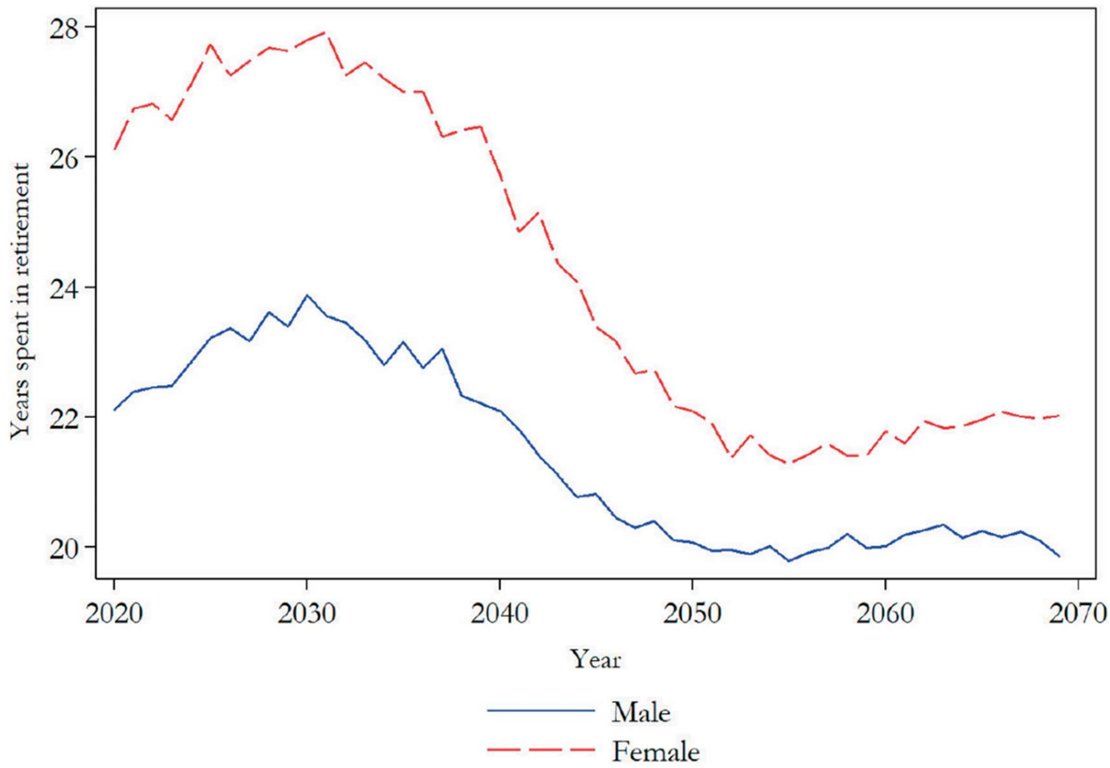

Figure 11 Retirement duration by gender

Although retirement ages have risen for both men and women, the average years of contribution at retirement initially decrease in the first years of the simulation before recovering (Figure 12). This trend is primarily due to the maturation of the generation of workers born between 1970 and 1980, who faced significant economic challenges following the 2009 crisis, and the growing impact of immigrant workers, who often spend only part of their careers in Italy and do not carry over any pension rights (in our simulations). When immigrant workers are excluded from the calculations, the average years of contribution at retirement remain roughly constant until the mid-2040s, after which they begin to increase.

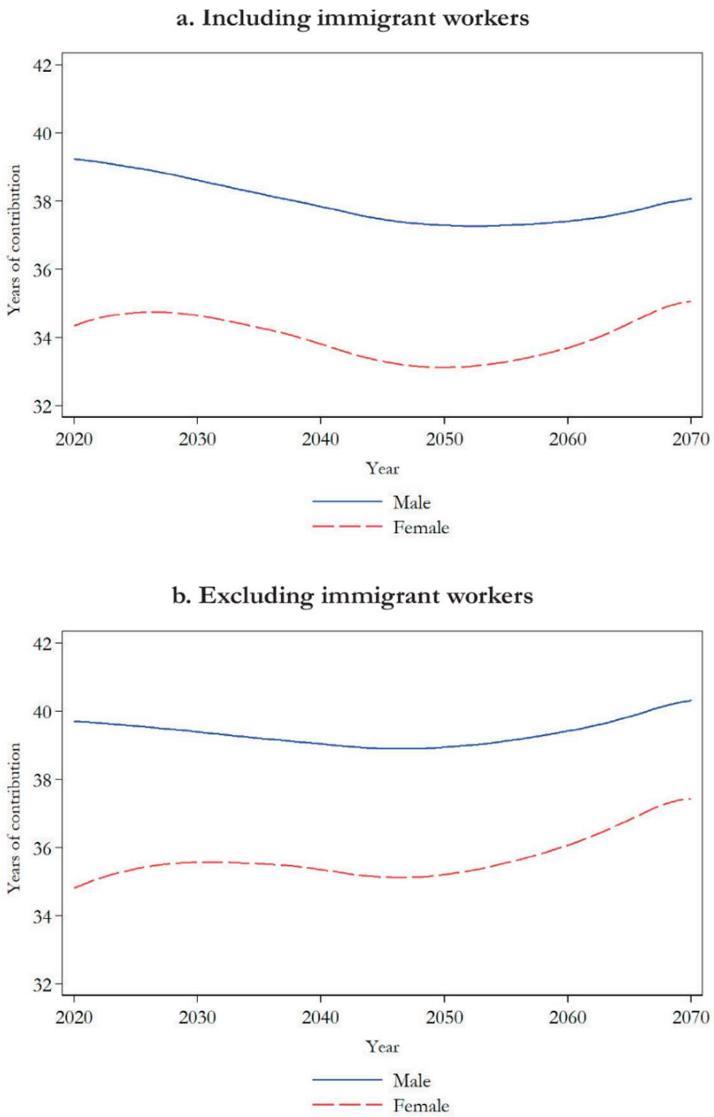

Figure 12 Average years of contribution at retirement by gender [22]

Analysing the Aggregate Replacement Ratio (ARR, Figure 13), it is observable that this rate remains steady during the initial years of the simulation. However, it begins to decline and eventually stabilizes around 50% after 2050. When examining the ARR by gender, the dynamics differ across the decades of the simulation. Initially, women are less protected by the pension system compared to men. Despite this disparity, projections indicate that women will experience a recovery in their ARR by 2030, achieving parity with men in terms of pension protection.

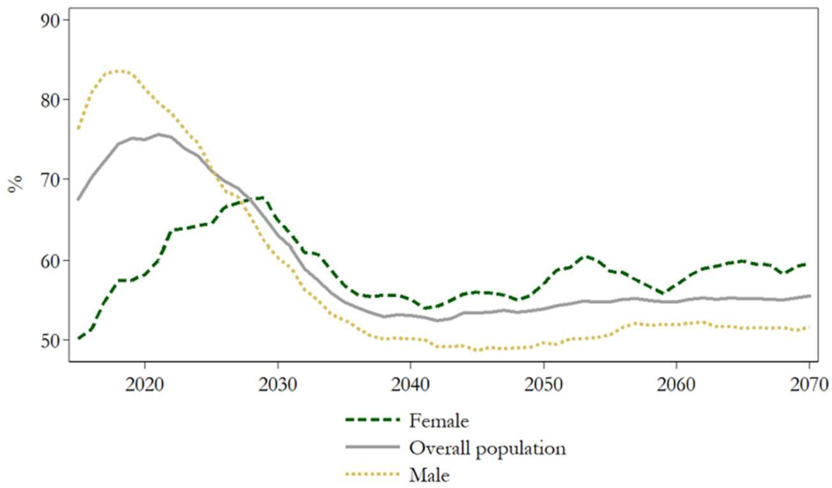

Figure 13 Aggregate Replacement Ratio by gender [21]

To conclude the chapter, the condition at retirement by birth cohort and income quintile in terms of average age and median gross replacement rate is presented in Table 10. The shift from DB to NDC computation rules is anticipated to lower average pension benefits. However, it is also expected to reduce inequalities among pensioners, as those with higher incomes will be the most affected by this change. The data reveals that individuals in the higher income quintiles are more significantly impacted in terms of reductions in pension amounts. The position of younger cohorts is expected to worsen in terms of both pension levels and the average age at retirement. This decline is partly influenced by the assumption, necessitated by a lack of data, that migrant workers do not carry over any pension rights when they enter the country. This assumption might be overly pessimistic and could potentially skew the results. [22] [21]

Cohort	Overall		1st/2nd quintile		4th/5th quintile	
	Average age	Median rr	Average age	Median rr	Average age	Median rr
1960-1964	66.1	65.4	67.2	56.7	65.7	67.5
1965-1969	66.6	59.8	67.3	53.5	66.4	61.9
1970-1974	67.1	55.2	68.0	50.3	66.7	56.3
1975-1979	67.6	51.2	68.4	48.0	67.3	52.2
1980-1984	68.0	50.8	68.6	48.0	67.8	51.6
1985-1989	68.7	50.5	69.2	47.0	68.4	51.6

Table 10 Condition at retirement by birth cohort and income quintile (five-year birth cohorts, from 1960 to 1989) [21]

Conclusions

This thesis offers an in-depth analysis of the evolution and sustainability of the Italian public pension system, using various projection models to forecast future outcomes. The first chapter reviews the historical context and key reforms, such as the Amato, Dini, and Fornero reforms, which were introduced to address demographic challenges and ensure financial sustainability. In the second chapter, the roles of major institutions like INPS, ISTAT and Sogei are highlighted. These organizations play a vital part in forecasting the future of the pension system. Their collaboration with the Treasury and the State General Accounting Department has led to the development of sophisticated projection models, which are detailed in the middle chapters. These models are critical for understanding how demographic and macroeconomic changes will impact the system. The final chapter presents the outcomes of the projection models for the Italian public pension system. Using both the State General Accounting Department model and the Treasury Dynamic Microsimulation Model, the projections provide insights into the system's sustainability from 2016 to 2070. In the near term, pension expenditure is expected to rise due to demographic pressures, particularly the aging of the population and the retirement of the baby-boom generation. This increase will peak in the 2030s and 2040s, driven by a growing imbalance between the number of retirees compared to workers. However, over the long term, pension expenditure as a percentage of GDP is projected to decline. Starting from 2044, this decrease will be primarily due to the full implementation of the Notional Defined Contribution rules and the gradual exit of the baby-boomer generation. By 2070, pension costs will reach more sustainable levels. The final chapter also highlights significant gender disparities within the pension system. Men generally benefit from early retirement options and have higher pensions due to more stable career paths, while women tend to retire later, have lower pensions and experience longer working lives. This disparity reflects career interruptions and lower lifetime earnings for women. Additionally, the findings show that the average retirement age is expected to rise for both men and women, driven by reforms that tie retirement age to life expectancy. Although pensions will become less generous as the system transitions fully to the NDC model, this shift is necessary for long-term financial sustainability.

In conclusion, the Italian public pension system, while currently facing significant challenges, is on a path toward greater financial stability due to ongoing reforms.

However, continued policy adjustments will be necessary to address demographic pressures and ensure pension adequacy and equity for future retirees.

References

[1] COVIP (Commissione di vigilanza sui fondi pensione), "L'evoluzione del sistema pensionistico in Italia," [Online]. Available: https://www.covip.it/sites/default/files/evoluzionedelsistemapensionistico.pdf.

[2] N. Gianni, "The Italian Pension System," in *International Comparison of Pension Systems: An Investigation from Consumers' Viewpoint*, Singapore, Springer Nature Singapore, 2022, pp. 108-116.

[3] Itinerari previdenziali, "Le riforme del sistema previdenziale: dal 1992 al 2005," pp. 212-216.

[4] J. Hamann, "The reform of the pension system in Italy," International monetary fund, 1997.

[5] M. L. Maitino, L. Ravagli and N. Sciclone, "The effects of the two most recent Italian pension reforms on financial and social sustainability in the medium-long run," in *IMA 7th World Congress*, Galway, 2019.

[6] M. Borzaga, "The Italian social security system after the recent economic and financial crisis and the related reforms: are austerity measures the right answer?," University of Trento, 2016.

[7] T. Jappelli, M. Padula and R. Bottazzi, "Retirement Expectations and Pension Reforms," 2003.

[8] INPS, "inps.it," [Online]. Available: https://www.inps.it/it/it/l-istituto/la-storia-e-i-numeri-dell-inps.html.

[9] INPS, "inps.it," [Online]. Available: https://www.inps.it/it/it/dati-e-bilanci/osservatori-statistici-e-altre-statistiche.html. [Accessed 13 04 2024].

[10] INPS, "inps.it," [Online]. Available: https://servizi2.inps.it/servizi/osservatoristatistici/66. [Accessed 14 04 2024].

[11] ISTAT, [Online]. Available: https://www.istat.it/en/about-istat/. [Accessed 30 07 2024].

[12] Ministero dell'Economia e delle Finanze, "Ragioneria Generale dello Stato," [Online]. Available: https://www.rgs.mef.gov.it/VERSIONE-I/ragioneria_generale/ruolo_della_ragioneria/chi_siamo/index.html. [Accessed 31 07 2024].

[13] MEF, [Online]. Available: https://www.mef.gov.it/en/ministero/struttura/dipartimenti.html. [Accessed 9 8 2024].

[14] Sogei, [Online]. Available: https://www.sogei.it/it/sogei-homepage/azienda/profilo.html. [Accessed 31 07 2024].

[15] MEF Dipartimento della ragioneria generale dello stato, "Le tendenze di medio-lungo periodo del sistema pensionistico e socio-sanitario," 2024.

[16] Ministry of economy and finance state general accounting department, "Mid/Long-term trends for the pension, health and long-term care systems," 2022.

[17] European Commission, "2024 Ageing Report Underlying assumptions and Projection Methodologies," 2023.

[18] Economic Policy Committee - Ageing Working Group, "2024 Ageing Report Italy-Country Fiche," Ministry of Economy and Finance – State General Accounting Department – Genaral Inspectorate for Social Expenditure, 2024.

[19] Ragioneria Generale dello Stato, "Dinamiche demografiche e spesa pensionistica: il caso italiano," Roma, 1998.

[20] MEF, INPS, Fondazione Giacomo Brodolini, Centre for economic and social inclusion, "Improving Effectiveness in Social security".

[21] R. Conti, M. Bavaro, S. Boscolo, E. Fabrizi, C. Puccioni, O. Ricchi and S. Tedeschi, "The Italian Treasury Dynamic Microsimulation (T-DYMM): data, structure and basline results," 2023.

[22] M. Bavaro, S. Boscolo, R. Conti, E. Fabrizi and C. Puccioni, "MOSPI – MODERNIZING SOCIAL PROTECTION SYSTEMS IN ITALY," 2021.

[23] R. Conti, M. Bavaro, S. Boscolo, E. Fabrizi, C. Puccioni and S. Tedeschi, "The Italian Treasury Dynamic Microsimulation Model: Data, Structure and Validation," *International Journal of Microsimulation,* vol. 17, 2024.

[24] INAPP, "Rapporto sul modello di previsione T-DYMM 3.0," 2020.