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In the mid2030s, the health of the baby boomers will have deteriorated and many in these large cohorts will be in need of formal and/or informal long-term care.
This “**care wave**” will transform two generations: the baby boomers in need of care and their children who may supply care. It will have significant implications for labour supply, especially for women, saving behaviour, and therefore for productivity, economic growth and its inclusiveness.

The overarching objective of BB-Future is to understand the size and the implications of the care wave on economic and social outcomes, to appreciate the quality of this second ageing-related transformation and to develop policy recommendations for advance planning on the EU and Member State levels.

This deliverable is a description of the calibrated overlapping generations (OLG) model that computes macroeconomic variables such as prices, wages, economic growth and its inclusiveness for the aggregate EU member countries as a function of growing long-term care needs.

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A calibrated OLG Model to Describe the Macroeconomic Implications of the Care Wave

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December 8, 2023

Abstract

This document describes the construction of an overlapping generations (OLG) model that projects the macroeconomic implications of the major demographic changes happening in Europe in the 21st century, with a focus on two key trends: the retirement of the 'baby boomer' generation and the increasing need for long-term care (LTC). As the 'baby boomers' retire, significant changes are happening in European societies, especially in how pensions are handled and the growing demand for LTC. This research examines the economic and social effects of these changes, putting a spotlight on how an aging population interacts with labor supply and social inequalities.

The model includes features such as heterogeneity of health and the resulting provision of care. The hypotheses this research investigates are that these demographic changes, especially the rising need for LTC, will slow down economic growth in Europe and that the increasing cost of LTC will hit lower-income families harder, making social inequalities worse, and affecting the labor supply of women.

By using a detailed OLG model that will be calibrated to represent continental Europe, we aim to show the trade-offs between financial stability, social welfare, and fairness across generations in the face of Europe's changing demographics. The model's results are meant to help policymakers find a balance between meeting the needs of an aging population and maintaining the overall economic and social health of European societies.

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1. Introduction

The onset of the 21st century marks an important demographic transition in Europe, characterized predominantly by the retirement of the 'baby boomer' generation. As this cohort gradually moves into retirement, with most individuals ceasing work between 60 and 65 years and self-assessing their health positively, a significant transformation is underway. This 'pension wave' has been the focal point of numerous studies analyzing retirement decisions and the ensuing transformation of pension systems in Europe’s aging societies. However, a second, less explored transformation appears on the horizon: the 'care wave'. By the mid-2030s, the deteriorating health of the baby boomers will escalate the need for long-term care (LTC), impacting not only this generation but their children as well, and consequently influencing labor supply, saving behavior, economic growth, and social inclusiveness. The importance of understanding the 'care wave' stems from a sharp rise over the next decades in the population share of individuals aged 85 and older in the EU27 (Eurostat, 2021a). Hence, more older people will demand long-term care while fewer younger people can supply it. The 'care wave' comes from the gap or imbalance between the demand and supply of long-term care.

Two additional aspects reinforce this demographic change problem. First is that there are indications that the trend toward better health is stalling or even reversing, although with great heterogeneity within the European population (Börsch-Supan et al., 2021). This might threaten to increase even more the care needs in the future. Second, is that the female labor supply is still rising in all major European countries (Eurostat, 2021b). Furthermore, there is evidence that the gender pay gap (and, also, the gender pension gap) is decreasing (OECD, 2021). Pressures to supply more care may endanger this progress especially as women generally provide more frequent and longer hours of informal care than men ((Schmid et al., 2012), (Verbakel et al., 2017)).

In response to these demographic shifts, the macroeconomic model described in this document aims to understand the magnitude and characteristics of this second aging-related transformation. While the study of population aging's impact on economic growth and welfare has a long tradition in economic research, highlighted by seminal works like those of Auerbach et al. (1983) and Auerbach and Kotlikoff (1987), a gap remains. Previous models, though influential in deriving policy recommendations, especially regarding pension reforms, have not adequately accounted for the care needs that arise with aging populations. This research contributes to filling this gap by extending these models, following the foundational work of Börsch-Supan et al. (2023), to include more nuanced elements such as health and long-term care insurance within the overlapping generations (OLG) framework.

The main innovation of this OLG model lies in elucidating the qualitative and quantitative trade-offs between financial sustainability, social welfare, and equality across and within generations characterized by significant heterogeneity. This heterogeneity is captured through modeling individuals within each cohort who vary not only in age but also in productivity, health deficiencies, life expectancy, and preferences for consumption and leisure. An important contribution of this model is to explore the interplay between macroeconomic outcomes, and LTC provision. This model will be calibrated to represent a weighted mix of France, Germany, and Italy or the EU3, to allow for a detailed exploration of the effects of the impending care wave in Europe. Ultimately, this model seeks to answer relevant and concrete questions: What are the macroeconomic implications of the care wave? How are these implications distributed not only between older and younger generations but also between high and low-income households?

In the context of Europe's rapidly aging population, this research aims to explore several critical hypotheses, each addressing a key aspect of the macroeconomic and social landscape. The first hypothesis of this study proposes that demographic changes, particularly the LTC needs in Europe, will lead to a deceleration in economic growth for OECD countries. This economic slowdown might be driven by several factors: firstly, increased demand for healthcare and long-term care services, leading to heightened social spending (Connolly & Li, 2016). However, it is important to note that this perspective is not universally accepted in the literature. For instance, Alper and Demiral (2016) argue that social spending can contribute positively to economic growth. Secondly, a potential reduction in labor force participation due to caregiving responsibilities and demographic shifts (Lee & Shin, 2021), especially female labor force participation (Thévenon et al., 2012); and thirdly, the disproportionate financial burden placed on younger generations (Kitao, 2014). Younger individuals, in their prime working years, may face higher taxes and increased contributions to social security systems, which are strained by the growing number of retirees compared to the working-age population. These factors might contribute to the economic deceleration, with the sustainability of Europe's healthcare system and the potential for increased government budget deficits further complicating the scenario ((Beqiraj et al., 2018), (Alinaghi & Reed, 2021)). This research posits that these intertwined dynamics will collectively impact Europe's economic growth trajectory.

A second hypothesis posits that escalating long-term care expenditures will have a higher impact on lower-income households in European countries, exacerbating economic inequality over time. There is a large body of literature related to socioeconomic inequality and inequity in healthcare utilization ((Devaux & De Looper, 2012), (d'Uva & Jones, 2009), (Pulok et al., 2020)), but the evidence of a socioeconomic gradient related to LTC is still small and seems it has received limited attention. However, this hypothesis is substantiated by various factors. Firstly, as long-term care expenditures rise, lower-income households might face greater financial strain compared to wealthier households (Thomson et al., 2019). This strain might be intensified by their limited access to comprehensive private insurance to offset these rising costs (Ameriks et al., 2016). Moreover, private LTC services or even formal care services are concentrated among the higher socioeconomic groups (Carrieri et al., 2017). On the contrary, the reliance on informal care is usually found in low socioeconomic groups ((Garcia-Gomez et al., 2015), (Rodrigues et al., 2018), (Tenand et al., 2020)). In the Netherlands, Abbing et al. (2023) suggest that the use of informal care steeply decreases for the higher socioeconomic group over time even when for low socioeconomic groups is stable. The use of more informal care on low socioeconomic groups might lead to family members, particularly women, scaling back their work commitments or leaving the workforce entirely to provide necessary care ((Schmid et al., 2012), (Verbakel et al., 2017)).

There is a growing literature exploring the rising demand for LTC in areas such as saving behavior ((Lockwood, 2018), (Bueren, 2023)), formal and informal care ((Carrino et al., 2018), (Barczyk & Kredler, 2019), (Perdrix & Roquebert, 2022)), the effects of informal care on labor market outcomes (Løken et al., 2017) and the importance of informal care (Barczyk & Kredler, 2018).[1] However, current

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[1] Klimaviciute and Pestieau (2023) provides an overview of the economics of long-term care.

models may not fully capture the complexities of behavioral responses to changing care needs and especially the different aspects of its macroeconomic implications.

This OLG model will give us a clear way to understand the macroeconomic impact of Europe's aging population, particularly in terms of healthcare and long-term care. It will show how these changes can affect public spending, savings, and labor decisions, and how they might change the need for pensions, healthcare, and long-term care services, influencing government budgets and the economy. A major benefit of this model is to show the financial impact of healthcare and LTC for people of different ages. This means that rising LTC costs might require higher taxes for working people or less money for retirees to spend. Furthermore, it is especially useful in understanding how caregiving responsibilities can affect labor supply and the economy. Without these extensions, the model would miss key elements like the escalating healthcare and LTC costs, leading to incomplete and potentially misleading economic forecasts. This model stands out from others by integrating these critical aspects, offering a more comprehensive picture of the economic impact of the Care Wave. The remainder of the document is structured as follows: Section 2 provides some economic and institutional background to the LTC environment in the EU3. Section 3 details the model and its components.

2. Stylized Facts

As Europe grapples with an aging population (Grundy & Murphy, 2017), understanding the economic ramifications of health and long-term care expenditures becomes more and more important. Figure 1 and Figure 2 offer two distinct yet interconnected insights. On the one hand, we observe the cross-country heterogeneity in health and LTC expenditures across various European nations for a specific year. On the other, we see the evolution over time of these expenditures for three countries of interest in this research, notably France, Italy, and Germany.

These metrics are valuable for a few key reasons. First, they offer a comparative lens through which we can assess how various countries are prioritizing and managing the health and long-term care needs of their populations, especially critical in the face of a rapidly aging demographic. Second, these percentages serve as a standard measure that enables us to make meaningful comparisons across nations with vastly different economic scales and healthcare systems. Third, by examining the trends over the last decade, we gain insights into the evolving nature of these expenditures, adding a layer of complexity that static figures alone cannot provide. This time-series data informs our understanding of whether the 'Care Wave' is a growing concern and how sustainable current practices are.

Figure 1 plots health and long-term care (LTC) expenditures as a percentage of Gross Domestic Product (GDP) across multiple European countries for 2017. The cross-country comparison for 2017 underscores the varying priorities and challenges each country faces. Nations like Germany and France, lower than the European Union's average. Such heterogeneity could be attributed to differences in demographic structures, policy frameworks, and economic capacities. emerge as significant spenders, above the European Union average, in both health and LTC as a percentage of their GDP. Other countries such as Italy, even though their expenditures are high, remain lower than the European Union’s average. Such heterogeneity could be attributed to differences in demographic structures, policy frameworks, and economic capacities.

Even though there is cross-country heterogeneity in health and LTC expenditures in these countries, the evolution of these expenditures over time provides a more important view of the demographic change problem. Figure 2 shows the trend from 2012 to 2019 for both health and LTC expenditures in France, Italy, and Germany. The trends for health expenditures seem to be stable for the European Union even though Germany's health expenditure is rising rapidly. However, the trends for LTC expenditure have been on a consistent rise. This upward trajectory, especially in these major economies, might raise concerns from a macroeconomic standpoint.

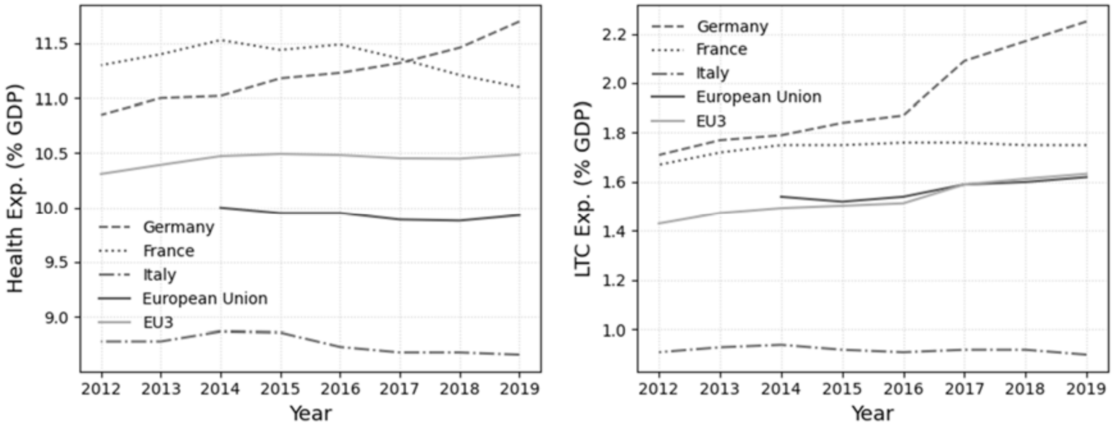

Figure 1 Health and Long-Term Care Evolution

Note: Annual evolution of health care and long-term care expenditure as a percentage of gross domestic product (GDP) from 2012 to 2019. Institutional source: Eurostat.

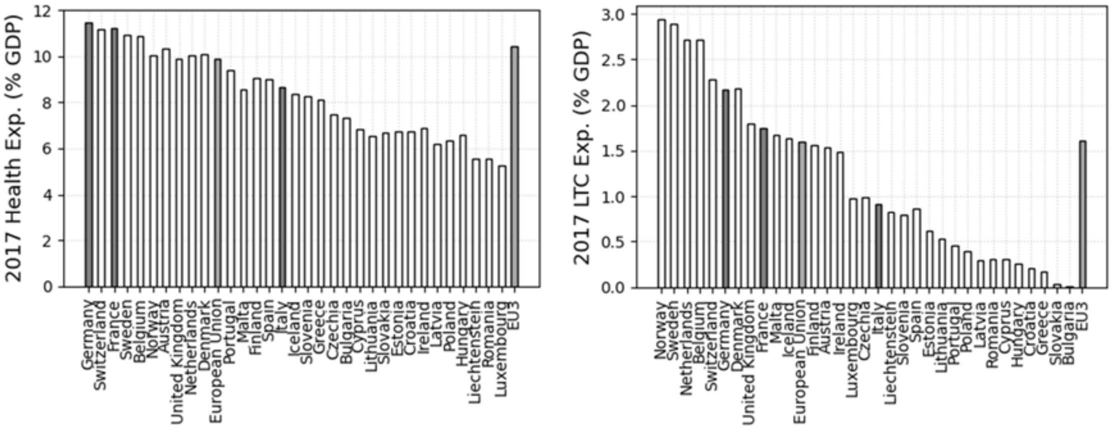

Figure 2 Health and Long-Term Care, 2019

Note: Annual health care and long-term care expenditure as a percentage of gross domestic product (GDP) for the year 2017. Institutional source: Eurostat.

In most developed nations, government involvement in long-term care (LTC) remains limited. On average, public spending on LTC in the EU3 amounted to just 1.5% of their GDP in 2014, a figure mirrored in European nations. The past 20 years have seen considerable reforms in LTC policy, although these changes haven't significantly impacted the level of public expenditure in this area. However, as these expenditures rise, they could potentially strain public finances, divert funds from other crucial sectors, or influence fiscal policies. Additionally, with the European population's age structure leaning towards an older demographic, the demand for LTC is likely to grow, further intensifying the economic implications.

2.1. Institutional Background of Long-Term Care in EU3

This subsection provides an overview of the institutional background surrounding LTC in three major European Union countries: France, Germany, and Italy. Each country has a distinct approach to LTC insurance and provision, shaped by its unique social and economic structures (Carrera et al., 2013). These descriptions highlight the diversity in eligibility criteria, benefits, and funding sources across the EU, offering an insightful comparison of how different nations address the challenges of LTC.[2]

According to Joël et al. (2010), in France, the approach to LTC insurance is to incorporate it into the broader health insurance landscape. The program called Personalized Allowance for Autonomy (APA) is intended for people over 60 years of age to support expenses linked with their new loss of independence. Eligibility for benefits hinges on an assessment of an individual's degree of dependency. This assessment is based on ten variables of physical and mental activity, and seven variables of domestic and social activity. Depending on their categorized dependency, recipients might find variance in their benefits: a higher degree of dependency translates to more substantial assistance. Currently, in France, there are six levels of care dependency, 1 being the highest level of dependency and 6, being self-sufficient. Only the first four levels of care dependency are eligible for APA. In 2019, the maximum amounts for the APA ranged from 674 Euros per month in level four to 1742 Euros per month in level one. This amount not only depends on the level of dependency but can also be influenced by the recipient's income. The amount of the allowance is adjusted by the income of the recipients. For people with a monthly income below 800 Euros, 100% of the care plan is paid by the local authority. The rate of co-payments increases with income up to 90% for those with a monthly income of over 2948 Euros. On average, APA pays for around 80% of the care plan cost. This system is financed from payroll taxes levied on employees and complemented by contributions from retirement pensions ((Joël et al., 2010), (Barber et al., 2021)).

Germany presents a dualistic model of LTC insurance. Citizens are mandated to have LTC insurance, either integrated with the statutory health insurance system or sourced from private providers. Eligibility and subsequent benefits are dictated by specific care levels, established after an assessment of factors like mobility, cognitive capabilities, and daily life activities. Rates are closely tied to these care levels; higher levels mean higher benefits. Before 2017 there were three care dependency levels, now that has been extended to five. Individuals have to take a needs-based, uniform assessment test, which assigns them to one out of five care dependency levels (Pflegegrade) ranging from 1 being only a little impairment of independence to 5 being full hardship. The assessment covers areas of mobility, cognitive and communication skills, behavior and psychological issues, self-care, coping mechanisms, and social contact. Individuals are granted the flexibility to choose between in-kind benefits (services) and cash benefits, though it's important to note that the monetary value of cash benefits is typically half that of in-kind services. For example, the maximum in-kind benefits for home care per month ranges from 689 Euros per month in level two to 1995 Euros per month in level five. This system is financed through a shared payroll tax system between employers and employees. Those who've opted for private health

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[2] Barczyk and Kredler (2019) presents an overview of the LTC programs in Europe.

insurance are obligated to secure private LTC insurance ((Schulz, 2010), (Barber et al., 2021), (Geyer et al., 2023)).

In contrast, Italy's approach to LTC is decentralized and region-centric. The actors directly involved in the organization of LTC services are Municipalities, Local Health Authorities (Aziende Sanitarie Locali, ASL), Nursing homes (Residenze Sanitarie Assistenziali, RSA), and the National Institute of Social Security (Istituto Nazionale Previdenza Sociale, INPS), the central State, Regions, and Provinces. Provisions are dispersed and embedded within existing health and social care frameworks. Eligibility is neither linked to the beneficiaries' payment of social security contribution nor to a means test, and it is not subject to age restrictions. To be eligible to receive benefits, beneficiaries must be assessed and must not reside in institutions with costs charged to the public administration. The need severity, however, is assessed differently across regions, some being more generous, while others lean towards being more restrictive, resulting in different numbers of recipients across regions. This regional variance also means the amount and type of aid can be influenced making it not uniform across the country. The benefits can be in cash (indennita di accompagnamento), mean-tested care benefits (assegni di cura) and in-kind services (assistenza domiciliare integrata, Presidi sociosanitari and Centri diurni). Funding for LTC predominantly comes from general taxation. Additionally, in Italy, a significant part of LTC expenditure is funded directly by region-specific co-payments from households ((Tediosi & Gabriele, 2010), (Colombo et al., 2011), (Barber et al., 2021)).

3. Model

This overlapping generations model (OLG) is an extension of the Auerbach and Kotlikoff (1987) type, specifically extending Börsch-Supan et al. (2023) in several dimensions. The focus of this model is to add a more complete social security system that includes not only a detailed public pension scheme but also health and long-term care pillars. The integration of health and long-term care as core components in the social security model is driven by a fundamental recognition: as individuals age, their health declines, necessitating increased reliance on care services. This inclusion is not merely an extension but a critical adaptation to reflect the complex interplay between aging, health, and economic support systems. The nuanced dynamics of aging and health directly influence individual decision-making within the model. To account for these, this model, as in Börsch-Supan et al. (2023), allows for a discrete endogenous choice on retirement in addition to the continuous leisure/work and consumption/saving trade-offs. This detailed setting permits a comprehensive analysis of the differential effects of potential reforms on the four outcome criteria within the same modeling framework.

3.1. Households

Within each cohort, there are K different types of perfectly foresighted households at every point in time t with age j. These households exhibit ex-ante heterogeneity, meaning initial differences in their productivity, consumption/leisure preferences, survival probabilities, and health deficiencies, detailed in Subsections 3.1.1 and 3.4.1. The households receive utility from consumption $c_{t,j}^{k}$ and leisure $l_{t,j}^{k}$. The utility function is twice continuously differentiable, strictly increasing in consumption and leisure, and strictly concave and is given by:

$$u\left(c_{t,j}^{k}, l_{t,j}^{k}\right) = \frac{1}{1-\theta}\left[\left(c_{t,j}^{k}\right)^{\phi_j^k}\left(l_{t,j}^{k}\right)^{1-\phi_j^k}\right]^{1-\theta} \tag{1}$$

where ϕ_j^k captures the individual's intra-temporal preference between consumption and leisure at age j for a type k individual. It dictates how the individual trades between consumption and leisure when maximizing their utility. If ϕ_j^k is high, the individual strongly prefers consumption over leisure. This parameter will dictate how the individual allocates time between labor and leisure at each age, given their wage rate, health status, and time providing informal care. θ determines the inverse of the individual's intertemporal elasticity of substitution. This determines how willing the individual is to substitute consumption over different periods, or in other words, how the individual is willing to smooth consumption over time. The households are subject to different constraints: monetary and time constraints. The monetary or budget constraint is given by

$$a_{t+1,j+1}^{k} = a_{t,j}^{k}\,(1+r_t) + h_{t,j}^{k}\,w_{t,j}^{k}(1-\tau_t) + p_{t,j}^{k} - c_{t,j}^{k} - (1-\eta^m)\,m_{t,j}^{k} - \left(1-\eta_j^n\right)n_{t,j}^{k} \tag{2}$$

where $a_{t,j}^k$ denotes assets. Wages depend on age and household type, $w_{t,j}^k = w_t\,\epsilon_j^k$ where ϵ_j^k generates age and type-specific wage profiles. $p_{t,j}^k$ are pension benefits. Furthermore, $m_{t,j}^k$ and $n_{t,j}^k$ are the total health and LTC medical expenses obtained from the health status, and η^m and η_j^n are the shares of the medical expenses covered by the health and LTC public insurance respectively. This means that $(1-\eta^m)$ and $\left(1-\eta_j^n\right)$ are the shares of the medical costs that the individual pays. From labor income, τ_t is the contribution rate of the social security system which combines public pension, health, and long-term care systems $\tau_t = \tau_t^p + \tau_t^h + \tau_t^{ltc}$. The time endowment per period is normalized to one. Leisure $l_{t,j}^k$ is equal to time endowment minus hours worked $h_{t,j}^k$, minus the share of time spent in providing care Λ_j^k. The time constraint is expressed as:

$$l_{t,j}^{k} = 1 - h_{t,j}^{k} - \Lambda_j^k \tag{3}$$

3.1.1 Health Deficiency

At the core of this OLG model lies a crucial component: the health deficiency process. Health, a key determinant of an individual's quality of life and economic decisions, especially in later years. It is modeled here as the lack of health with detailed attention to health deterioration over time. A deterministic health deficiency profile χ_j^k is determined by:

$$\chi_j^k = \beta_0^k + \beta_1^k e^{\beta_2^k age_j^k} \tag{4}$$

It establishes a nuanced view of the aging process, portraying how health deficiencies evolves non-linearly. The key parameters influencing this evolution include β_1^k and β_2^k, which represent the scale and acceleration of health decline with age, respectively. β_0^k indicates an individual's baseline health, influenced by genetics, environmental factors at birth, etc. A lower value of β_0^k suggests a healthier start, with fewer initial health deficits. Using health deficiencies as a stock χ_j^k is a useful way to understand LTC needs, reflecting the gradual and cumulative nature of health changes over an individual's lifetime. This approach facilitates a clear understanding of how health problems accumulate with age. Importantly, it also provides a robust framework for projecting health and LTC expenditures, as each marginal increase in χ_j^k correlates with higher associated costs. Given the model's focus on LTC needs, typically linked with chronic illnesses and gradual health deterioration, this stock-based approach to health aligns perfectly with the model's objectives and enhances its predictive power in assessing LTC requirements.

The deterministic health deficiency profiles χ_j^k in this model assumes that health deficiencies inevitably increase throughout an individual's life, leading to a gradual deterioration in their health. However, the model assumes that the need for long-term care services, which is also dependent on an individual's health deficiency status, arises in the latter stage of life. This is defined in the model as the point where an individual's health deficiency status, χ_j^k, meets or exceeds a specified threshold, $\bar{x}$. Importantly, due to the stratification of health profiles, this threshold $\bar{x}$ is reached at varying ages for different individuals. For example, individuals with poorer health cross the threshold for requiring LTC services earlier than those with better health.

3.1.2. Health and LTC Expenditures

In the OLG model, the financial implications of an individual's health deficiency are expressed through health m_j^k and long-term care (LTC) n_j^k expenditures. The health expenditures m_j^k are permanently present in the budget constraint. However, as LTC needs only appear if $\chi_j^k \geq \bar{x}$, otherwise there are no LTC expenses $n_t = 0$. These two terms are included in the individual's budget constraint (2). These expenditures are quantified as follows:

$$m_j^k = \theta_0^m + \theta_1^m \cdot \chi_j^k \tag{5}$$

$$n_j^k = \theta_0^n + \theta_1^n \cdot \chi_j^k + \theta_2^n \cdot \chi_j^{k\,2} \quad if\,\chi_j^k > \bar{x},\ 0\ otherwise \tag{6}$$

The health deficiency status for individuals of type *k* and age *j*, represented by χ_j^k, is used to calculate the health and LTC costs via the cost functions (5) and (6). In this model, parameters θ_0^m and θ_0^n are the base cost, representing the minimum cost incurred irrespective of the health or long-term care condition. It is indeed possible that when the health deficiency profile is at zero the individual might still incur some basic healthcare or long-term care costs – for instance, the costs of preventive healthcare services, regular check-ups, etc. Parameters θ_1^m and θ_1^n represent the direct effects of deteriorating health on costs, capturing straightforward increases in healthcare and LTC usage as health declines. Lastly θ_2^n tries to capture additional non-linear effects of LTC on the costs. It implies that as health deteriorates, costs don't just increase but do so at an accelerating rate.

The inclusion of a quadratic term in the LTC cost function (6) is particularly noteworthy. This incorporation of the quadratic term is crucial for enhancing the model's capacity to depict the progressive nature of LTC costs. For example, the diagnostic of multimorbidities in chronic diseases is higher as individuals age ((McPhail, 2016), (Barnett et al., 2012)) and these can complicate simple treatments and increase their costs ((Cortaredona & Ventelou, 2017), (Buja et al., 2020)). Such multimorbidities can be associated also with substantially higher healthcare utilization and social care costs among older adults (Picco et al., 2016). This additional non-linear term allows the model to capture the nuances of health deterioration and its impact more effectively on LTC expenses, particularly as this deterioration becomes more pronounced over time.

3.1.3. Provision of Informal Care

In this OLG model, a realistic approach to modeling informal care provision is included by making it dependent on the health status of the older generation. Informal care provision, denoted by Λ_j^k is thus a function of the health deficiency profile of the parent, $\chi_{j+d,p}^k$. Λ_j^k provides the average hours a person provides care to their parents and the term $\chi_{j+d,p}^k$ is the health deficiency of the parent, who is *d* years older than the child. The care provision by a child at age *j* for a parent in household type *k* is:

$$\Lambda_j^k = f\left(\chi_{j+d,p}^k\right) \quad if \quad \chi_{j+d,p}^k \geq \bar{x}, 0\ otherwise \tag{7}$$

We will specify $\bar{x}$ in Subsection 3.4.2. As the informal care Λ_j^k depends on parental health deficiency profile, there are three different informal care profiles obtained from equation 7. This would mean, for example, that individuals with parents with excellent health, will have to start providing care later in life compared to individuals with parents with poor health (see Figure 9). In this model, heterogeneity among households, or household type k is assumed to be consistent across generations, ensuring that the characteristics of a given lineage remain stable over time. For instance, if a household belongs to a high productivity profile, this attribute is preserved in their descendants, contributing to the dynastic nature of the model.

3.1.4. Life Cycle

A simplified guide to understand the life cycle of households is presented in Figure 3 which shows their different stages. Initially, we can divide households between the working and retirement stages. From 20 years of age to *R*, depending on their endogenous decisions for retirement *R*, people work. Their remaining time they receive retirement pensions. A different aspect of their life relates to the time spent on providing care. In this model, individuals provide care to their previous generation. From the deterministic health deficiency process, it is known that individuals in the model start needing care when $\chi_j^k \geq \bar{x}$. This threshold is set to match the prevalence rates of LTC needs rising exponentially after 80 years of age ((Fuino & Wagner, 2018b), (Fuino & Wagner, 2018a)). This means that the hours of informal care provided to care for parents start around age 50. Care is provided to parents until they are out of the model, around age of 70 of the children. After that, the individual no longer provides care and only wait until their care needs arrive.

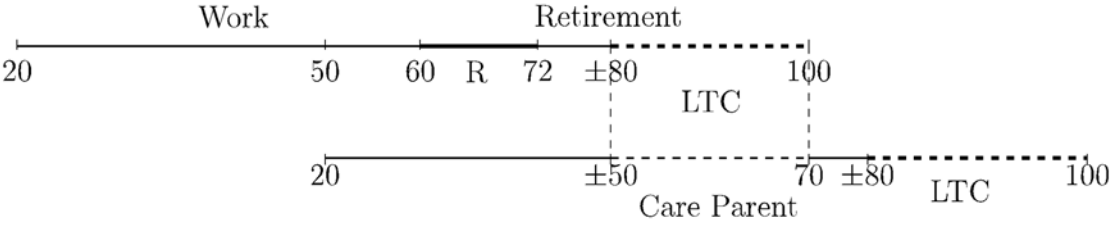

Figure 3 The Life Cycle of an Individual

In a model that tries to study long-term care, it is important to consider not only the individual need to receive care but also how providing care would affect the labor supply and consumption. In this case, individuals will have less time available for work, which could potentially reduce labor supply, especially during the age ranges where LTC hours are high. Due to reduced time for labor, individuals might choose to work more intensively in earlier years to save for the periods when they must provide more care. With reduced labor hours due to LTC commitments, individuals might face a reduction in their earnings, which can potentially decrease their consumption levels, especially in the later stages of life. Knowing this, they might choose to save more in their earlier years to smoothen their consumption over the life cycle.

A different way to understand these dynamics and the life cycle of individuals is by detailing their recursive problem. At time *t*, an individual of type *k* of age *j* solves a dynamic programming problem. The state space at the beginning of age j is $a_{t,j}^{k}$ and the value function is given by $V\left(a_{t,j}^{k}\right)$. From 20 to around 50 years of age, the agent only works, and the remaining time is spent in leisure activities. Moreover, the agents are not expected to provide care, as the previous generation is still young and do not need care. For individuals in this period, the Bellman equation is:

$$V_{t,j}^{k}\left(a_{t,j}^{k}\right) = \max_{c_{t,j}^{k}, l_{t,j}^{k}} \left\{ u\left(c_{t,j}^{k}, l_{t,j}^{k}\right) + \beta \pi_{t+1,j+1}^{k} V_{t+1,j+1}^{k}\left(a_{t+1,j+1}^{k}\right) \right\} \tag{8}$$

where β represents the discount factor, which measures the individual's preference for consuming goods and enjoying leisure today rather than in the future, and $\pi_{t+j,j}^{k}$ the survival probabilities. This Bellman equation is constrained by

$$l_{t,j}^{k} = 1 - h_{t,j}^{k} \tag{9}$$

$$a_{t+1,j+1}^{k} = a_{t,j}^{k}\,(1 + r_t) + h_{t,j}^{k}\, w_{t,j}^{k}(1 - \tau_t) - c_{t,j}^{k} - (1 - \eta^{m})\, m_{t,j}^{k} \tag{10}$$

From when parents need care, around 50 years of age of the child, until their retirement decision *R* is endogenously made, individuals are still in their working stage, so they receive labor income. Their time is divided between working and leisure and providing care to their parents. The Bellman equation for individuals in this stage is:

$$V_{t,j}^{k}\left(a_{t,j}^{k}\right) = \max_{c_{t,j}^{k}, l_{t,j}^{k}} \left\{ u\left(c_{t,j}^{k}, l_{t,j}^{k}\right) + \beta \pi_{t+1,j+1}^{k} V_{t+1,j+1}^{k}\left(a_{t+1,j+1}^{k}\right) \right\} \tag{11}$$

subject to

$$l_{t,j}^{k} = 1 - h_{t,j}^{k} - \Lambda_{j}^{k} \tag{12}$$

$$a_{t+1,j+1}^{k} = a_{t,j}^{k}\,(1 + r_t) + h_{t,j}^{k}\, w_{t,j}^{k}(1 - \tau_t) - c_{t,j}^{k} - (1 - \eta^{m})\, m_{t,j}^{k} \tag{13}$$

A Feature of this model is the endogenous retirement decision R_{t}^{k}. Households choose to retire within a "window of retirement" denoted by $R_E \leq R_{t}^{k} \leq R_L$, where R_E is the earliest eligibility age for retirement and R_L is the latest. The retirement age chosen by the household is a by-product of the main optimization routine. From the age of the decision R_{t}^{k} to when $\chi_{j}^{k} < \bar{x}$, the retirement period starts for individuals. They no longer receive labor income but retirement pensions. Their time is spent now in leisure activities and in providing care to their parents. In this stage, individuals do not spend time working as they are retired. Their Bellman equation in this stage is:

$$V_{t,j}^{k}\left(a_{t,j}^{k}\right) = \max_{c_{t,j}^{k}, l_{t,j}^{k}} \left\{u\left(c_{t,j}^{k}, l_{t,j}^{k}\right) + \beta \pi_{t+1,j+1}^{k} V_{t+1,j+1}^{k}\left(a_{t+1,j+1}^{k}\right)\right\} \tag{14}$$

subject to

$$l_{t,j}^{k} = 1 - \Lambda_{j}^{k} \tag{15}$$

$$a_{t+1,j+1}^{k} = a_{t,j}^{k}\,(1 + r_t) + p_{t,j}^{k} - c_{t,j}^{k} - (1 - \eta^{m})\, m_{t,j}^{k} \tag{16}$$

Individuals after retirement, from when $\chi_{j}^{k} \geq \bar{x}$ to 100 years of age, need LTC services. Thus, their budget constraint includes the term $n_{t,j}^{k}$ to pay for $1 - \eta^{m}$ of the care services. Additionally, their time endowment is fully spent on leisure activities. The Bellman equation at this final stage is:

$$V_{t,j}^{k}\left(a_{t,j}^{k}\right) = \max_{c_{t,j}^{k}, l_{t,j}^{k}} \left\{u\left(c_{t,j}^{k}, l_{t,j}^{k}\right) + \beta \pi_{t+1,j+1}^{k} V_{t+1,j+1}^{k}\left(a_{t+1,j+1}^{k}\right)\right\} \tag{17}$$

subject to

$$l_{t,j}^{k} = 1 \tag{18}$$

$$a_{t+1,j+1}^{k} = a_{t,j}^{k}\,(1 + r_t) + p_{t,j}^{k} - c_{t,j}^{k} - (1 - \eta^{m})\, m_{t,j}^{k} - \left(1 - \eta_{j}^{n}\right) n_{t,j}^{k} \tag{19}$$

3.2. Government

We abstract from a reserve fund and debt such that the budget equation is assumed to be balanced in each year:

$$\tau_t w_t \sum_{k=1}^{K} \sum_{j=1}^{R_t^k} \epsilon_j^k h_{t,j}^k N_{t,j}^k = \underbrace{\sum_{k=1}^{K} \sum_{R_t^k+1}^{J} p_{t,j}^k N_{t,j}^k}_{Pension} + \underbrace{\sum_{k=1}^{K} \sum_{j=1}^{J} \eta^m m_{t,j}^k N_{t,j}^k}_{Health} + \underbrace{\sum_{k=1}^{K} \sum_{j=1}^{J} \eta_j^n n_{t,j}^k N_{t,j}^k}_{LTC} \tag{20}$$

where τ_t represents the sum of contribution rates of all the branches of the social security system $\tau_t = \tau_t^{p} + \tau_t^{h} + \tau_t^{ltc}$ and $N_{t,j}^{k}$ represents the number of people aged *j* at time *t* and in household-type *k*. Additionally $m_{t,j}^{k}$ and $n_{t,j}^{k}$ are the health and LTC medical expenses, and η^{m} and η_{j}^{n} are the shares of the medical expenses covered by the health and LTC insurance respectively. If the government's budget is not balanced, the τ_t might need to be adjusted, cut benefits, or consider other sources of revenue or borrowing.[3]

The pension system is a defined benefit (DB) pay-as-you-go (PAYG) pension system and follows Börsch-Supan et al. (2023). DB means that a cohort of retirees is promised a pension benefit $p_{t,j}^{k}$, which is defined by a replacement rate b_t that is set by the pension policy and not necessarily dependent on the demographic and macroeconomic environment. The contribution rate to the system is then adjusted to keep the PAYG system balanced. Individual pension benefits $p_{t,j}^{k}$ are given by:

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[3] Future extensions would consider different sources of government funding.

$$p_{t,j}^{k} = \gamma_{R_t^k}^{k} \cdot b_t \cdot w_t \bar{h}_t \cdot \frac{s_{t,R_t^k}^{k}}{R_t^k} \tag{21}$$

Where $w_t \overline{\mathrm{h}}_\mathrm{t}$ denotes average earnings. The earnings points $s_{t,j}^{k}$ represent the pension claims that are accumulated in a career average plan, and $s_{t,R_t^k}^{k}/R_t^k$ is the number of pension points at retirement age R_t^k, averaged over the working life. $\gamma_{R_t^k}^{k}$ adjusts pension benefits to the chosen retirement age. These adjustment factors counterbalance a longer or shorter duration of receiving pension benefits if households retire before or after the full pensionable age. $\gamma_{R_t^k}^{k}$ equals 1 if the household retires at the full pensionable age. If the household decides to retire earlier, there is a deduction of pension benefits for every year of earlier retirement. For each year of delayed retirement, there is a premium. A detailed description of this public pension system is found in Börsch-Supan et al. (2023).

3.3. Firms

The production sector consists of a representative firm. Production is given by a Cobb-Douglas production function using capital stock, K_t, and aggregate labor, L_t, as inputs.

$$Y_t = K_t^{\alpha}\ (A_t\ L_t)^{1-\alpha} \tag{22}$$

A_t is technology (growing at a time-varying rate g_t). α is the capital share in the economy. Since factors earn their marginal product, wage, and rates of return for capital are given by

$$r_t = \alpha k_t^{\alpha-1} - \delta \tag{23}$$

$$w_t = A_t(1-\alpha)k_t^{\alpha} \tag{24}$$

where k_t denotes the capital stock per efficient unit of labor, $k_t = \frac{K_t}{(A_t L_t)}$, and δ is the depreciation rate. Equilibrium is reached when supply equals demand on all relevant markets.

3.4. Model Parameters and Life-Cycle Profiles

3.4.1. Heterogeneity of Life-cycle Profiles

This model introduces several dimensions of ex-ante household heterogeneity: health deficiencies, productivity levels, consumption and leisure preferences, and life expectancy. These elements are essential for capturing the varied impacts of social security reforms on different household types, making the model more robust. They enable the exploration of the differential effects of changes in public pension schemes, health, and long-term care policies within a single, unified framework.

The first life-cycle profile is the health deficiency profile χ_j^k. It is based on the health deficiency index by Börsch-Supan et al. (2021) and calculated using questions on physical and cognitive health across different waves of SHARE data. It is based on 44 binary variables related to various health dimensions. χ_j^k is defined as the number of these binary variables reported by an individual divided by the maximum possible number of variables. Thus, ranging from 0 to 1 where 0 represents optimal health or maximum health, and 1 denotes the poorest health or minimum health, capturing the spectrum of health conditions in this model. The deterministic health deficiency profile in this model is a function of age and stratified by three initial health status. These three different profiles are created to reveal critical insights into how individuals differ in their health trajectories. These profiles are poor, medium, and excellent health. As shown in Figure 4 health deteriorates more rapidly for individuals in the poor health deficiency profile as suggested by equation 4.

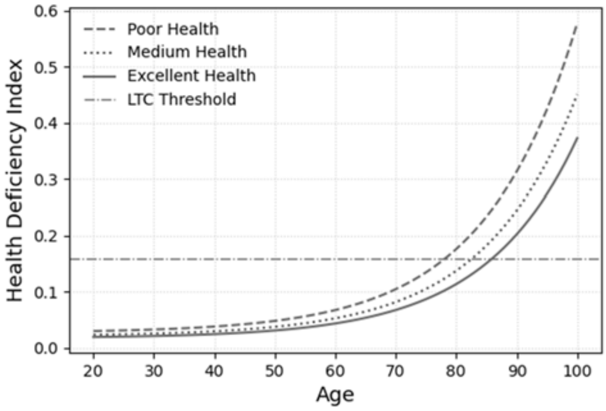

Figure 4 Health Deficiency Profiles

Source: Author's calculations

The model incorporates the second life-cycle profile as varied productivity levels ϵ_j^k, reflecting the diverse economic contributions of individuals throughout their life cycle. These profiles provide insights into how productivity first increases when young, later reaches a peak in middle age, and decreases again as a consequence of the aging process ((Altig et al., 2001), (French, 2005) and (Huggett et al., 2011)). These productivity profiles are separated into three income groups, as depicted in Figure 5. The resulting productivity profiles increase with age at a steeper rate for higher-income groups and decrease slightly after the peak.

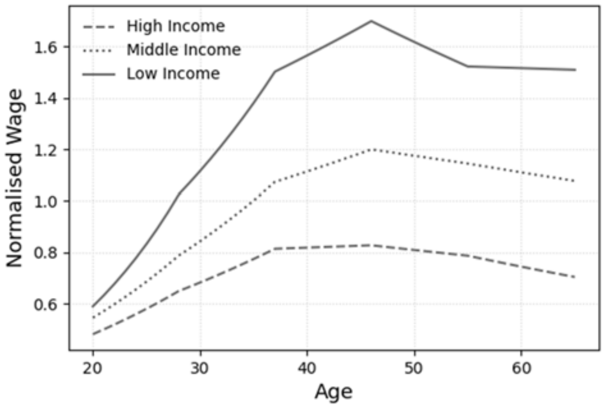

Figure 5 Productivity Profiles

Source: Author's calculations.

These profiles calculate cohort-corrected wage profiles for France, Italy, and Germany for men aged 50 or over, containing their average earnings from ages 20 to 49 using SHARE data and the job episodes panel ((Börsch-Supan et al., 2013); (Brugiavini et al., 2019)). The income groups are calculated for the upper productivity profile for the highest income category, the lower productivity profile for the lowest income category, and the middle profile for a combination of the lower and the upper middle class.

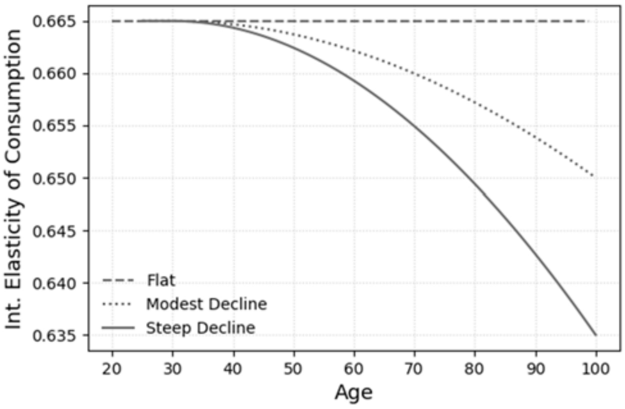

Figure 6 Consumption Profiles

Source: Author's calculations.

The third life-cycle profile shows the preference for consumption profiles for each household type ϕ_j^k. It measures how willing an individual is to substitute between consumption and leisure. These profiles represent the aging process, during which the preference for leisure increases, thereby reducing labor supply and eventually inducing retirement. The consumption preferences are separated also into three different profiles as shown in Figure 6. To obtain these consumption profiles a parametric approach is implemented. It assumes the same starting value for all the groups. For the individuals in the first group, there is no decline. There is a modest decline for the second group and steep decline for the last group. The level and slope over the life cycle of these groups will be calibrated such that both the average retirement age and the expenditures in pension payments are matched with the data.

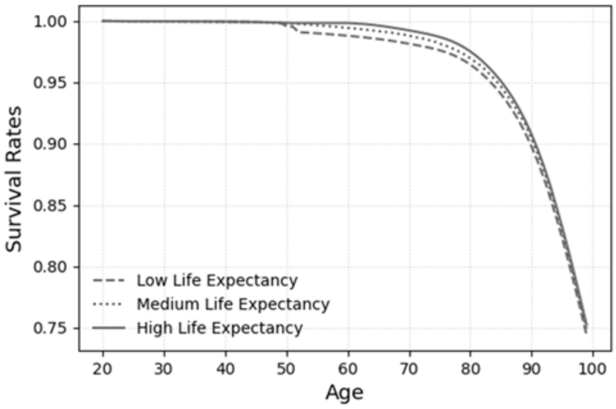

Figure 7 Mortality Risk Profiles

Source: Author's calculations.

The final life-cycle profile shows the heterogeneity in mortality risk π_j^k, which increases with age. The unconditional survival rates are calculated by cohort and individual-specific, for the three different household types using the Human Mortality Database (2016). These estimated unconditional survival rates are used to determine the conditional survival rates for the three household types. The conditional survival rates are shown in Figure 7.

Once the different sources of ex-ante household heterogeneity are included in the model, it is important to specify their interaction. In this model, there are *k* different types of perfectly foresighted households at every point in time *t* with age *j*. This means, that the model considers a combinatorial product of heterogeneities across the four different dimensions. The initial total number of unique household types would amount to 81. These different profiles and their connections are summarized in Figure 8.

However, solving this OLG model, which incorporates endogenous choices related to consumption and savings, work and leisure, and retirement, already requires significant computational resources. To make the process more efficient and save time, the best approach to solve the model is to select a specific mix of household types out of the 81 possibilities. This selection is designed to capture the most important correlations effectively without overly complicating the computational process. This would mean that in the model, the final number of household types is to be reduced from 81 to only 24 possibilities. The shares of each household type are obtained using SHARE data. The household types excluded from the computation of the model are the ones with a small sample share. This allows a comprehensive mix of ex-ante heterogeneity that encapsulates a wide spectrum of household *k* to ensure a more detailed analysis.

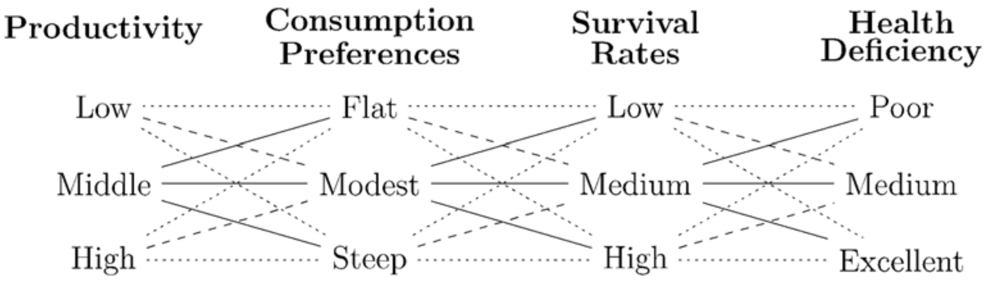

Figure 8 Household Types

3.4.2. Parameters

On the side of individual preferences, the intra-temporal elasticity parameter between consumption and leisure, which defines the preferences for consumption ϕ_j^k will be calibrated to match the average retirement age of individuals in the model. The decline of consumption preferences, as seen in Figure 6, will be calibrated to match pension expenditures. The discount rate, ρ, will be calibrated to match the consumption-output ratio (Frederick et al., 2002). Lastly, the inverse of the intertemporal elasticity of substitution (IES) parameter, θ, is set to 2, which lies in the middle of estimates in the literature (Conesa et al., 2009).

As detailed in section 2.1, some features of the health and LTC systems among EU3 countries are similar, while others differ in the areas of eligibility, benefits, and funding sources. In our OLG model, we approximate the eligibility criteria for LTC benefits by providing coverage to all individuals if $\chi_j^k \geq \bar{x}$. This is in line with the regulations of the three countries as the age of individuals who have LTC needs in the model is already assumed to be more than 60 years of age. In the model, the parameter that dictates whether an individual needs LTC is $\bar{x}$. This threshold is set to match the prevalence rates of LTC needs rising exponentially after 80 years of age ((Fuino & Wagner, 2018b), (Fuino & Wagner, 2018a)). This sets the value of the threshold to $\bar{\mathrm{x}} = 0.16$.

To translate the LTC benefits of the EU3 into the OLG model, eligibility for benefits is created depending on the level of care dependency of individuals. A way to create a simple framework that works not only for the EU3 but for other countries as well, is to create categories of care that provide enough variation on the level of dependency required. In this case, the categories are mild, moderate, and severe dependency. Individuals with mild dependency usually need assistance with some daily activities but can perform many tasks independently. This might include help with housekeeping, meal preparation, or transportation. Those with moderate dependency require more substantial assistance with daily activities. This could include help with personal care such as bathing, dressing, and possibly some medical monitoring. Severe dependency refers to individuals who need extensive assistance or total care. They might be bed-bound or have significant physical or cognitive impairments, requiring 24-hour care. Different values of χ_j^k can set thresholds for the levels of dependency. In this model, level one ("mild") starts at the threshold $L1 = 0.16$, which we identify with to $\bar{\mathrm{x}}$ equation 7. Level two ("moderate") starts at $L2 = 0.26$, and level three ("severe dependency") starts at $L3 = 0.36$. The categories of dependency are shown in Figure 9.

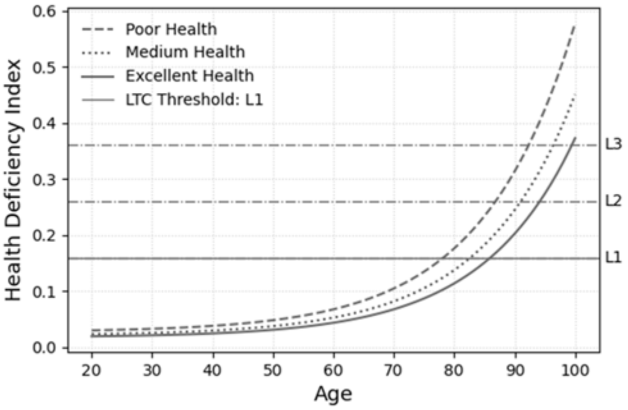

Figure 9 Health Deficiency Profiles with Levels of Care Dependency

Source: Author's calculations.

Based on Figure 9, individuals, independently of their health deficiency profiles, will eventually be on the three levels of care dependency, only at different ages. The share of LTC services covered by the public insurance η_j^n is obtained by the level of care dependency, meaning three different values for η_j^n. Based on Table 3 of Rothgang (2010), in 2007, the average share of co-payment care cost for LTC in Germany for the different levels of care dependency were: 22% for mild, 26% for moderate and 33% for severe levels of care dependency. These provide the values for η_j^n of L1 is $\eta_j^n = 0.78$, for L2 is $\eta_j^n = 0.74$ and for L3 of care dependency is $\eta_j^n = 0.67$. The share of health expenses covered by the public health insurance η^m in this model does not vary by level of care dependency. It is set to $\eta^m =$

88% as the average of all inpatient costs covered by government or compulsory insurance schemes across the E.U. (OECD & European Union, 2020).[4]

The health and LTC expenditures parameters from equations 5 and 6 are obtained using wave 6 of SHARE data. The question from SHARE data that provides part of the information related to health medical expenditures is "How much did you pay yourself for your doctor visits, medication, hospital stays, and dental care in the last twelve months (that is how much did you pay without getting reimbursed by [a health insurance/your national health system/ a third party payer])?". Regarding LTC expenditures, the information from the SHARE data was obtained from: "How much did you pay for yourself for at-home care or nursing home stays in the last twelve months without getting reimbursed by your insurance?". However, these questions refer only to out-of-pocket health and LTC expenditures. Based on this data on out-of-pocket health (OOP^m) and LTC (OOP^n) expenditures, the value of their respective total expenditures is calculated:

$$m_j^k = \frac{OOP_j^m}{(1-\eta^m)} \tag{25}$$

$$n_j^k = \frac{OOP_{,j}^n}{\left(1-\eta_j^n\right)} \tag{26}$$

This approach assumes that the relationship between the out-of-pocket costs and the total costs is linear and directly proportional to the insurance coverage rates η^m and η_j^n. This transformation of the out-of-pocket expenditures would allow us to calculate the total costs of health and LTC in equations 25 and 26 permitting the estimation of the parameters from equations 5 and 6. The health and LTC parameter values are obtained by regressing the total health or LTC medical expenditures on the health deficiency index. Through this, we ensure that our model's translation of health deficiency stock into medical expenditures is empirically grounded. The parameters obtained for total health expenditures are $\theta_0^m = 0.798$ and $\theta_1^m = 0.289$ and for total LTC expenditures are $\theta_0^n = 3.876, \theta_1^n = 2.288$ and $\theta_2^n = 0.452$.

Regarding the informal care profile presented in equation 7, a comprehensive model that might capture the complexity of caregiving dynamics in several important ways is:

$$\Lambda_j^k = \theta_0^c + \theta_1^c \cdot \chi_{j+d,p}^k + \theta_2^c \cdot \chi_{j+d,p}^{k\,2} \tag{27}$$

where θ_0^c is the base level of care provided independent of health status, reflecting social norms or obligatory care levels, θ_1^c captures the direct, linear relationship between parental health and care hours. As health begins to deteriorate, this term reflects the initial increase in care hours provided by the caregiver. Lastly, θ_2^c captures changes in the rate of care provision as health further deteriorates or improves. This term is crucial for understanding the diminishing or accelerating returns in care hours in response to significant changes in health status. Including a squared term in this functional form of the model allows us to capture the nuanced relationship between parental health and informal care provision. This approach recognizes that the increase in care time due to declining health may not be constant: initially, care time may rise with worsening health, but beyond a certain point, the rate of this increase might diminish. Such a model offers a more realistic representation of caregiving behavior,

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[4] Future extensions of this model will account for more details of the health and LTC system such as co-payments, catastrophic problems, and private insurance.

reflecting limitations in caregiver capacity or shifts to professional care at advanced stages of health deterioration.

The parameters θ_0^c, θ_1^c and θ_2^c of the informal care provision from equation 27 can be estimated using information from the time expenditure, and the demographics and networks modules from wave 8 of SHARE data. The question providing the information to obtain the hours of informal care is: "How much time did you spend yesterday on helping your parents or parents-in-law? This can include assistance with administrative chores, washing, dressing, taking them to see the doctor etc.". Due to the intergenerational nature of the equation 27, the information used for parental health is obtained from the question "How would you describe the health of your mother/father?". Preliminary values of these parameters are $\theta_0^c = 0.97$, $\theta_1^c = 1.29$ and $\theta_2^c = -0.17$. The negative coefficient for the squared term indicates that there is a diminishing increase in care time as health continues to deteriorate. This could happen if, for instance, as health deteriorates beyond a certain level, alternative forms of care (like professional healthcare services) start replacing informal care, or if the capacity of informal caregivers to provide additional care reaches its limit.

The transformed total cost of LTC in equation 26 represents the 'Formal Care' component in the model, which, when combined with the 'Informal Care' provided by children, gives us the total 'Care Received' for individuals with LTC needs at each time period t. The total 'Care Received' balances the provision of care with total needs for LTC of the older generation. The adjustment needed to properly add formal and informal care is to transform the total formal care into hours. To accurately represent the 'Formal Care' component in terms of hours within our model, the total LTC expenditures (formal care costs) are converted into an equivalent number of care hours. The transformation of formal care costs into care hours is accomplished by dividing the total formal LTC expenditure by the average hourly rate for formal caregiving services. This rate should reflect the average cost of hiring a professional caregiver in the EU3. This hourly rate is taken as the minimum wage for workers in the LTC sector and it is average between non-medical and medical care providers. This value sets in 13.97 euros per hour (Geyer et al., 2023). This approach ensures that both formal and informal care components are expressed in a common unit (hours), facilitating to obtain the balance between the care provided formally and informally, and the care received by the parents.

Regarding their life cycle, households enter the model and the labor market at age 20 and their maximum life span is 100 years. The age of the parents to have their child is 30 years old. This is important due to the connections between generations exogenously done via informal care. This means that when the child enters the model at age 20, the age of the parents is 50. In the model, demographic factors are exogenous and are described by the population size of each cohort, the survival rate of that cohort, and changes resulting from net migration. The size of the population aged j in period t is given recursively by $N_{t+1,j+1} = N_{t,j} \cdot \psi_{t,j}$ where ψ denotes the age-specific conditional survival rate. The original cohort size for cohort c depends on the fertility of women aged k at time $c = t - j$ given by $N_{c,0} = \sum_{k=0}^{\infty} f_{c,k} N_{c,k}$. This model is also very rich in describing population aging which has three demographic components: past and future increases in longevity, expressed by ψ; the historical transition from baby-boom to baby-bust expressed by past changes of $f_{c,k}$; and fertility below replacement in many countries expressed by current and future low levels of $f_{c,k}$. Population data, age distributions, and assumptions on projections for fertility, mortality, and migration rates are taken from the (Human Mortality Database, 2016).

Due to the endogenous retirement feature of the model, the retirement window for individuals is from R_E=60 to R_L=72. The age for early retirement, R_E, is selected due to the earlier legal retirement age for women in several European countries (OECD, 2019). While there is no legal upper bound for late retirement, we assume age 72 as the latest retirement age for computational ease. We assume $\omega = 3.2\%$ due to the weighted average value of current adjustment rates in the EU3 countries. On the firm side, the capital share, α, in the economy is assumed to be 0.33. This is the range found in several studies (King & Rebelo, 1999). The annual productivity growth is set to its actual average values before 2017 using data from the Penn-World tables and set to 1.5% after 2017 (Feenstra et al., 2015). Lastly, the depreciation rate of capital will be calibrated to match the capital-output ratio (Christiano et al., 2005).

Table 1 Parameters

Parameter	**Description**	**Value**
Preferences		
ϕ_j^k	Intra-temporal elasticity	0.665
-	Modest decline of	0.015
-	Steep decline of	0.03
ρ	Discount factor	0.0132
θ	Inverse of IES	2
Health Exp.		
η^m	Share of health coverage	0.88
θ_0^m	Minimum health cost	0.798
θ_1^m	Direct effects of healthcare usage	0.289
LTC Exp.		
η^n	Share of LTC coverage	-
θ_0^n	Minimum LTC cost	3.876
θ_1^n	Direct effects of long-term care usage	2.288
θ_2^n	Non-linear effect of long-term care usage	0.452
$\underline{x}$	Threshold for LTC	0.16
θ_0^c	Minimum informal care	0.97
θ_1^c	Direct effect of parental health	1.29
θ_2^c	Non-linear effect of parental health	-0.17
Pension		
R_E	Earliest retirement age	60
R_L	Latest retirement age	72
b	Initial steady-state replacement rate	0.6
ω	Adjustment rate	0.032
Firms		
α	Capital share in production	0.33
δ	Depreciation rate of capital	0.062
g	Growth rate of labor productivity	0.15

3.4.3. Further steps: calibration to macro data

The structural parameters of this model will be calibrated to match the most important simulated moments of our model to their empirical counterparts for the year 2017. A prototypical country will be considered in this model, a synthetic aggregation of the population data from the three largest continental European countries (France, Germany, and Italy) called EU3. The model will calculate different weighted average moments as targets for calibration. For instance, the capital-output ratio, consumption-output ratio, average hours worked, and the pension system's expenditures with pension payments as a percentage of GDP. Additionally, two additional calibration targets will be added to have certainty that the two additional branches of the social insurance are correctly accounted: health and LTC expenditures as a percentage of GDP. An overview of the values of the parameters obtained from the literature is presented in Table 1. Based on these parameters and preliminary estimation procedures, Table 2 is constructed to provide a initial look of the main calibration targets of this model. Calibration will adapt these parameters to better fit the macroeconomic outcomes shown in Table 2.

Table 2 Calibration Targets

	2017 EU3 Data	**Model**
Capital-output ratio	3.10	2.38
Consumption-output ratio	0.75	0.86
Average hours worked	0.64	0.61
Pension expenditure (% of GDP)	13.2%	15.4%
Health expenditure (% of GDP)	10.45%	1.7%
Long-term care expenditure (% of GDP)	1.59%	1.7%

Source: Author's calculations.

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