Increasing employment and family care? A structural analysis of pension and long-term care policy reforms

Björn Fischer[1] and Thorben Korfhage[2]

[1]Berlin School of Economics (BSE), Free University Berlin; bfischer@diw.de
[2]German Federal Ministry of Finance

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Abstract

We develop a comprehensive life-cycle model of elder parent care and work to evaluate options that address pressing conflicts between pension and long-term care (LTC) policies. Many OECD countries react to challenges of demographic change by increasing LTC by family members (informal care) and raising retirement ages. This intensifies conflicts between paid employment and informal care provision. We extend the previous literature, integrating formal and informal care options to point to impacts of institutionalized incentives on the care-mix. We combine endogenous with exogenous processes and improve on earlier models by incorporating important information on parents to model care-demand. We validate the model using a quasi-experimental setting in Germany. Policy simulations show a decrease in informal care supply as retirement ages are increased. Even though formal and informal care are no perfect substitutes in the model, the demand for formal care increases as a consequence. Further, women with potential care-demand suffer higher reductions in life-time earnings as well as welfare. Policy simulations suggest that pension points collected in times of informal care supply reduce detrimental effects of changes to pension rules on informal care supply and the care-mix. These policies can also reduce losses in welfare and life-time earnings for women with potential care-demand. Labor market frictions matter in the uptake of informal care. Our simulations show that removing these have similar positive effects on the care system while reducing labor supply.

JEL Classification: I18, I38, J14, J22, J26

Keywords: Long-term care; Informal care; formal care; long-term care insurance; labor supply; retirement; pension benefits; structural dynamic model

1 Introduction

Most OECD countries, including Germany, expect a 45% increase in the number of long-term care-dependent individuals between 2020 and 2050 (K. Jacobs et al., 2020). Currently, two-thirds of all individuals in need of Long-Term-Care (LTC) receive primarily care from family members (informal care). Thus, many societies react to higher demand for LTC by supporting informal care provision. At the same time, pension schemes face challenges to its financial sustainability as the age dependency ratio rises. However, increasing retirement ages intensifies time-conflicts between paid employment and informal care provision. Therefore, pension and LTC policy aims are in conflict. It is crucial for policy makers to understand options that can solve conflicts between these most pressing policy fields.

In this paper, we evaluate a comprehensive policy mix to simultaneously react to challenges in LTC and pension policies. Specifically, we study behavioral responses as well as welfare and distributional implications. For this purpose, we build and estimate a dynamic structural model in which agents can decide on labor supply, retirement, as well as formal and informal care provision for a frail parent. We improve on earlier models in two ways. First, we incorporate the choice for adult children to organize formal care for a frail parent. This is important as we also want to understand the implications of changes to the retirement system also on demand for formal care. Further, in order to understand the preferences and considerations of adult children in case a parent becomes sick, the model needs to include the full choice-set. Second, we model the care provision decision conditional on an exogenous care demand process. In this important aspect we improve on earlier models as we incorporates parental age and health as well as distance to parents and existence of siblings in the care-demand function. This allows us to obtain structural parameters that reflect preferences for LTC provision to parents conditional on demand for care. Our model incorporates further restrictions. Individuals can only decide to provide labor hours if they receive a job offer. They understand that after periods of unemployment, the probability of a job offer is reduced. Each choice comes with short and long-term payoffs as well as costs. We model the German tax and transfer system, including the pension system. Importantly, we incorporate the incentive structure of the German LTC insurance. Further, agents receive labor and spousal income alongside income from their assets. Agents take into account the implications of current actions for the future. We solve this dynamic modelling problem by backward induction.

The model is estimated using individual level data from the German part of the Survey of Health Ageing and Retirement in Europe (SHARE) and data from the German Socio-Economic Panel (SOEP). The SHARE data set includes unique information about parental health, age, the distance to them, and the existence of siblings that we use to estimate care demand. Further, SHARE respondents inform on informal care given to parents specifically. Concentrating on women aged 55 to 69, we estimate structural parameters by Maximum-Likelihood. Our model fits important dynamics of the data well.

To understand the dynamics of the model we then simulate the consequences of a 10% higher female labor force participation at age 54. We find decreases in informal care provision mostly on the intensive margin. Formal care demand shows only low immediate responses. We can validate the model out of sample by simulating an increase in the early retirement age (ERA) for German women as introduced in the 1999 pension reform. The reform increases time-conflicts in the ages 60-62 for women born from 1952 onward compared to women before. Our model replicates decreases in informal care supply and employment responses from this quasi-experimental setup (Fischer and Müller, 2020; Geyer and Welteke, 2021). In contrast to reduced form evidence we can point to increases in demand for formal care and differential effects of the reform by care-demand.

In a next step we leverage the structural model and simulate potential future policy changes. First, we raise retirement ages for all women to 67 (NRA) and 65 (ERA). Individuals in Germany born from 1964 onward face a NRA at age 67. Additionally, in Germany and other OECD countries, further increases to pensionable ages are being discussed. Our policy simulations can point to important dynamic side-effects not yet discussed in the literature. Those women who react with higher employment rates reduce informal care provision. Formal care demand increases as a consequence. We can show that women who have at least one living parent increase employment less than those without a parent who is alive. The group of women choosing unemployment as a reaction more often choose to provide informal care. Opportunity costs of informal care supply are lower in unemployment than in retirement, holding age constant. We then investigate the role of labor market frictions in the decision to provide informal care. Care-leave rules give the opportunity to return to the job after a leave, during which one provides informal care to a family member. We find that agents incorporate labor market frictions in their decision to supply informal care. Therefore, giving women the opportunity to return to their jobs after spells of informal care supply incentivizes more informal care provision and affects the care mix as well. Employment is reduced as a consequence. When we combine the introduction of care-leave with increased retirement ages we find that the combined reform leads to lower losses in life-time earnings and well-being for women with at least one parent who is alive. In the German LTC system, individuals providing long-term care to a frail elderly while not working full-time can collect pension points that will increase subsequent retirement benefits. We further investigate the role of this dynamic incentive to provide informal care in an additional simulation and find that these long-term incentives are important for high intensive informal care. We show that an increase in collectable pension points can alleviate detrimental effects on earnings and well-being brought about by higher retirement ages. Our results support the notion that pension and LTC policy aims are in conflict, which the incentive structure of the LTC policy is able to alleviate. We show that the increase in retirement ages has positive fiscal effects while the LTC insurance faces losses. The increase in collectable pension points in care-provision has favorable fiscal effects over the introduction of care-leave while both are worse than the sole increase in retirement ages from a fiscal standpoint.

Our paper contributes to several strands of the literature. Various papers investigated the simultaneous decision between informal care provision and labor supply that causes time-conflicts on the individual level (see Bauer and Sousa-Poza (2015) and Lilly et al. (2007) for reviews). There is a growing literature focusing on the care decision itself and the role of labor market attachment as well as retirement rules.[1] These papers show that the care decision is negatively influenced by labor market attachment which makes clear that informal care is not taken up unconditionally. Mommaerts and Truskinovsky (2020) and Costa-Font et al. (2015) show that informal care provision is connected to the business cycle, thus showing that opportunity costs of informal care provision matter. Fischer and Müller (2020), Carrino et al. (2019) and Bergeot and Fontaine (2020) point to the fact that the availability of retirement benefits can positively impact informal care provision, which, in turn, leads to the conclusion that an increase in retirement eligibility ages can reduce informal care supply. This threatens the aim of many OECD countries to meet growing demand for care for elderly informally through family and friends. Whereas this aspect has been investigated in reduced form analysis, the dynamic long-term considerations are yet to be understood. We contribute to this strand of literature by building a structural dynamic model investigating the interaction between the retirement system and the LTC system. Further, we aim to uncover the role of the dynamic incentive structure of the retirement system and LTC system for the negative impacts of increasing retirement ages on informal care supply.

Further papers focus on short term effects of informal care on labor market outcomes as well as retirement, finding negative effects.[2] Schmitz and Westphal (2017), Skira (2015) and Korfhage (2019) point to long term consequences of informal care provision. As papers on short-term effects of informal care supply show, there exists a time-conflict between gainful employment and care provision that is often solved by a reduction of working hours or an hastening of retirement. Due to labor market frictions as well as the organization of the pension system, this often leads to lower chances of future employment or a dropping-out of the labor force. Even if the job can be kept, human capital accumulation is interrupted, which has consequences for future earnings and pension income. Skira (2015) and Korfhage (2019) estimate structural models to analyze long term labor market costs of informal care supply. Both emphasize the importance of labor market frictions, institutional incentives, and long term consequences of informal care supply for wages and pension benefits. In contrast to their work, we focus on the caring decision in light of changing labor market attachment of elderly women and increasing retirement ages. While models by Skira (2015) and Korfhage (2019) incorporate

[1] Berecki-Gisolf et al. (2008), Bergeot and Fontaine (2020), Boaz (1996), Carmichael, Susan Charles, et al. (2010), Carrino et al. (2019), Doty et al. (1998), Fischer and Müller (2020), Golberstein (2008), He and McHenry (2016), Mentzakis et al. (2009), Michaud et al. (2010), Moscarola (2010), Nizalova (2012), and Stern (1995)

[2] Carmichael and Sue Charles (1998), Carmichael and Sue Charles (2003a), Carmichael and Sue Charles (2003b), Carr et al. (2018), Heitmueller (2007), J. C. Jacobs et al. (2017), Niimi (2017), and Van Houtven, Coe, et al. (2013)

informal care choices to understand consequences for informal care providers' future outcomes we also allow for children to choose formal care for their parents or combine formal and informal care.

Barczyk and Kredler (2018) build and calibrate a model of inter-generational non-cooperative decision making between a frail parent and a child. They want to understand the potential impact of LTC benefits on caring decisions and costs for Medicaid in the US. They build a rich model in which agents decide on formal and/or informal care and savings in a dynamic setting and find that subsidies for informal care can decrease reliance on Medicaid. Mommaerts (2015) builds a model of informal care provision and formal care organization for frail parents trying to understand the link between the availability of informal care and demand for private long-term care insurance in the U.S.. The focal point of Mommaerts (2015) is the demand for private long term care insurance. Parents and children take a cooperative decision on care organization. In our model, adult children decision making is the focal point. We focus on their trade-off, which includes the public LTC system in Germany and utility of parental care. The German LTCI supports both informal and formal care. Thus, the decision to provide informal care or organize formal care is greatly impacted by the various institutional incentives that have short term and long term consequences. Therefore, it is important to understand the several aspects of the choice set of potential informal care providers to model care choices. A body of literature discusses whether formal and informal care are rather substitutes or complements, finding mixed results.[3] In this way we contribute to that literature by investigating the role of LTC incentives in the choice between formal and informal care.

Further, we enlarge literature by contributing simulations on important policy reforms. Increasing the retirement age is discussed in many OECD countries in order to uphold the sustainability of the public pension system. Many papers investigate potential side effects of those increases with regards to fiscal consequences.[4] We contribute by showing dynamic consequences on informal care supply that can simultaneously impact formal care usage. This has not only side effects for the care market but also brings negative fiscal consequences for the LTCIS. Further, we look at heterogeneous labor market reactions of individuals with and without care demand to reforms of the retirement age.

The paper structures as follows: In section 2, we present the institutional setting before presenting the data in section 3. We then outline the behavioral model, discuss exogenous and endogenous processes, and explain estimation in section 4. In section 5, we present main estimation results and discuss the model-fit. We then present simulations results in section 6 before we conclude in section 7.

[3] Hollingsworth et al. (2017), Karlsberg Schaffer (2015), and Van Houtven and Norton (2004)

[4] Battistin et al. (2009), Eibich (2015), Fischer and Müller (2020), Moreau and Stancanelli (2015), Müller and Shaikh (2018), and Staubli and Zweimüller (2013)

2 Institutional setting

Our model captures the incentive structure of the German pension system, social security system, tax system and Long-Term Care system (LTCS). As we want to analyze the importance of the dynamic incentive structure of both, the pension and LTCS out model needs to capture those in detail. In this section we present the institutional settings.

2.1 LTC system

The German Long-Term care insurance sytsem (LTCS) was introduced in 1995 in order to partially insure individuals against the risk to become permanently care dependent in old age. It provides benefits to those permanently (at least six months) impaired with at least two activities of daily living (ADL) and one instrumental activity of daily living (IADL). The severity of impairment is graded by independent institutions - the Medical Service of the Health Funds - and benefits are granted regarding the individual classification in one of the five possible care dependency levels.

Table 1: Care levels in Germany

Care level	Requirements	Benefits (monthly)	Share	Costs of formal care in Euro (SD)[a]
1	low impairment of independence	No entitlement for cash benefits or in-kind transfers for home care; 125 Euro earmarked benefits	9.44%	79.31 (203.54)
2	significant impairment of independence	316 Euro cash benefits, 689 Euro in-kind; 125 Euro earmarked benefits	42.39%	70.77 (110.44)
3	severe impairment of independence	545 Euro cash benefits, 1289 Euro in-kind; 125 Euro earmarked benefits	27.93%	176.16 (451.62)
4	highest impairment of independence	728 Euro cash benefits, 1612 Euro in-kind; 125 Euro earmarked benefits	14.05%	224.26 (474.65)
5	special cases (hardship) ,people with exceptionally high maintenance effort[b]	901 Euro cash benefits, 1995 Euro in-kind; 125 Euro earmarked benefits	6.17%	
Total				122.38 (319.27)

This Table shows requirements (column 2) and benefits (column 3) for the five care-levels of the German LTC insurance. Column 4 shows proportions of individuals in LTC benefit receipt in the care levels and column 4 shows overhead costs of formal care usage as given in SHARE data.

[a]Standard Deviation in brackets. This information comes from SHARE data, see Section 3. We can approximate care levels using limitations with activities of daily living. In this process we cannot differentiate between care level 4 and 5.

[b]Indidviuals who have no cognitive impairments but are physically highly impaired; for them it is hard to reach the highest score on the list; therefore, the special case is constructed

Benefits are granted to enable frail elderly to be cared for either informally, formally or in a mix of the two. While informal care takes place in the home of the care dependent, mostly by family members, formal care can either be provided in an institutionalized old-age care home or by professional care providers in the person's home.[5] Table 1 gives information on requirements and benefits in the 5 care levels in Germany. It also reports the share of individuals in the 5 care levels among those receiving any payments from the German LTCI. The cash benefits (coloumn 3) are neither means tested nor earmarked. Individuals who are cared for in their own homes can either choose cash payments if they choose informal care or in-kind payments for formal care or a mix. In 2019, cash benefits for home care range from 316 Euro in care level 2 to 901 Euro in level 5. This money can be used to pay for appliances assuring life at home or it can be paid to an informal care provider (e.g. family member). In-kind payments are used to pay for formal care. Benefits range from 689 Euro in care level 1 to 1995 Euro in level 5[6]. If a combination of in-kind formal care benefits and monetary benefits is chosen, the monetary benefit for informal care is reduced accordingly. In Table 1 (coloumn 4), we show the proportions of care benefit recipients in the 5 care levels.[7]. The majority of the 3.7 million individuals receiving benefits in 2019 are in care level 2 (42.39%)and care level 3 (27.93%). Statistics show that 1.8 million (49%) receive cash benefits for informal care, 153,000 (4%) received in-kind benefits and 514,000 (13%) make use of the option to use a combination of cash and in-kind benefits.

In SHARE data we find that individuals using formal care face on average costs of 122.38 Euro per month which are not covered by the LTCS. Table 1 (coloumn 5) shows the overhead costs for the household if formal care is used by number of ADL's of the care dependent person. As benefits increase with rising care dependency, overhead costs seem to increase as well.

Further, the LTCS gives the opportunity to collect pension points (see section 2.2) for intensive informal care supply. This is possible if: (1) care providers give care to a relative who is eligible for benefits from LTCI, (2) if care is provided for at least 14 hours a week, (3) if the care dependent person lives at home, and (4) if care givers spend less than 30 hours a week in payed employment. If these four conditions are satisfied, individuals collect 0.27 up to 0.8 pension points for each year of informal care-giving. If individuals are retired, they do not benefit from this regulation.

In the German part of the SHARE[8], individuals give information on care received formally and informally (from within or outside the own household). We plot care received by age in Figure 1. Looking at all individuals reporting some kind of received help, we find that while 65% report only to receive informal care, 21% are cared for in a combination of informal and formal care and 12% receive only formal care. However, care receipt differs greatly among several covariates:

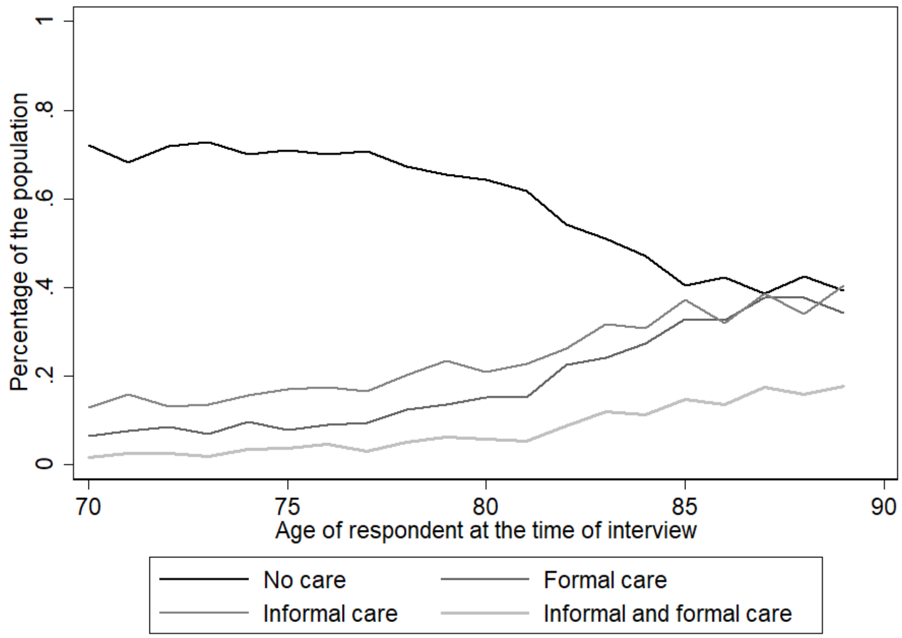
[5] In this model we discard the option to move into old-age homes as the information given on this is too sparse.

[6] In the model we specify the year specific monetary values for cash benefits and in-kind payments.

[7] See https://www.bundesgesundheitsministerium.de/fileadmin/Dateien/3_Downloads/Statistiken/Pflegeversicherung/Zahlen_und_Fakten/Zahlen_und_Fakten_der_SPV_Juli_2020_bf.pdf and https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Gesundheit/Pflege/Publikationen/Downloads-Pflege/pflege-deutschlandergebnisse-5224001199004.pdf?__blob=publicationFile

[8] See section 3 for information on the SHARE data-set. Here, we look at all observations in the German part of SHARE

Figure 1: Care mix by age of parent generation (SHARE data)



The proportion of individuals who need some kind of care grows with age (20% at age 60 vs. 40% at age 80, 68% at age 90). Formal care receipt, however, increases stronger with age than informal care receipt.[9] Table 2 shows the care mix (care from outside the household) of individuals from age 70 in SHARE by health status (Good, medium, bad).[10] In the upper panel, we find that with decreasing health higher percentages of individuals receive outside care; most striking is that formal care proportions increase dramatically as people report worse health. Informal care, while also in higher demand with worse health shows a less drastic increase. In the lower part, we show the care mix by health for those who receive outside care. We find again, that as health worsens, individuals receive more formal care. One reason could be that while elderly people in good health might still need assistance with several activities in the household, only those in bad health need formal care.[11]

[9] While at the age 69 80% need no care, 16% receive informal care and small portions receive a mix (1.6%) or only formal care (1.7%), at the age of 80, nearly 40% receive some care (21% informal care, 9.6% a mix and 7.4% only formal care). At the age of 90, only 32 % receive no care at all, with 17.9% receiving only informal care, 35.8% receiving a mix and 13.4% receiving only formal care.

[10] We incorporate only care from outside the household to understand which role care received from children might play. Care from a spouse or another household member is discarded.

[11] Figure 13 in the Appendix depicts the proportions.

Table 2: Care mix by health

	Good Health	Medium health	Bad health
Unconditional			
No Care	79.96%	65.69%	46.87%
Formal care	3.62%	8.87%	20.53%
Informal care	14.00%	17.01%	14.27%
Informal and formal care	2.42%	8.44%	18.33%
Conditional on care received in the household			
Formal care	18.08%	25.84%	38.64%
Informal care	69.87%	49.57%	65.50%
Informal and formal care	12.05%	24.60%	34.50%

This Table shows proportions of LTC usage by self-reported health. The upper panel shows unconditional information while the lower panel shows proportions conditional on care received in the household from outside the household.
Source: SHARE data, own calculations

Individuals with children receive less formal care; the same is true for those who have at least one child living close by. Those without children have a 9 percentage points (pp) lower probability to receive informal care if they receive any care. Further, we find that 39% of individuals reporting any kind of care receive some care from their children, while 17% some care from a spouse. Married individuals receive overall much less outside care. However, if married individuals receive care, higher proportions (31% vs. 22%) receive formal care than non-married individuals. The reason is that as married individuals need care, informal care tasks can often be performed by the spouse and if outside care is needed, care tasks often performed by professionals are demanded.[12]

2.2 Pension benefits

The public pension benefit system in Germany is a pay-as-you-go system. Benefits are linked to the labor market history. Benefits are calculated according to the German pension formula:

$$pension_t = (\sum PenP_t)xAFxPV_t \tag{1}$$

$PenP_t$ are so called pension points that are accumulated per year over the life cycle. They depend on the individual labor earnings and the mean gross labor earnings in Germany. An individual earning

[12]Figure 14 in the Appendix shows care usage by existence of at least 1 child (upper left), distance to children (upper right) and marriage status (lower panels). We look at the care mix by children and distance to a child on any outside care received; the care mix by marriage status is shown conditional on care received (lower right) and unconditionally (lower left).

exactly the mean gross labor earnings of any given year collects 1 pension point for that year. For earnings below or above this benchmark, collected pension points are adjusted proportionally.[13] Additionally, individuals can collect pension points for example through child care or informal elder care, as described above (section 2.1).

The retirement age factor AF is one if the individual retired at the normal retirement age (NRA). Per month of early retirement with respect to the NRA, the factor is decreased by 0.003; per month of later retirement, the factor is increased by 0.005. If an individual retires at age 63, while the corresponding NRA is at age 65, the AF is 0.072 and the pension is 7.2% lower than if the person had retired at age 65.[14] The deductions for early retirement stay constant over the life span. The timing of retirement, therefore, is crucial for benefit size which leads to dynamic incentives to work longer. Our model incorporates this incentive structure. The deductions are often not considered actuarial fair. Therefore, it is often argued that the system provides an incentive for individuals to retire at the earliest convenience (Börsch-Supan, Rausch, et al., 2020).

The NRA is subject to change due to several reforms in the previous years. Therefore, the NRA for each individual depends also on the birth year. Further, depending on the number of waiting years[15] accumulated, a different NRA can apply. The same is true for potential early retirement ages (ERA). Table 24 in the Appendix gives an overview of requirements and possible ERA and NRA that exist.

The pension value PV_t changes each year and reflects the development of wages, inflation and demographic trends in Germany. Each pension point accumulated during the lifetime is worth 34.19 Euro of retirement benefits in 2021.

Women in Germany heavily use the incentivized discrete retirement ages. Using the German Socio-Economic panel data set (SOEP) [16] We find jumps in the probability to be retired of 13 percentage points (pp) at age 60, 10pp around the threshold age 63 and at the threshold age 65 a jump of about 16 pp. The earliest possible retirement age for many women is age 63. We find that about 61% of women are retired by age 63.5, showing that high amounts of women use their earliest possibility to retire.

[13] Pension points are calculated as $min\{H_t w_t / \overline{H_t w_t}, Max_t\}$, where $\overline{H_t w_t}$ is the region specific mean gross labor earning in period t and Max_t denotes a year specific cap on pension points which varies roughly around two.

[14] The highest value for AF possible is 1.3 which is reached 5 years after the NRA.

[15] Waiting times are the number of years that any person is active on the regular labor market and pays into the public pension system.

[16] Figure 16 in the Appendix depicts retirement behavior of women. For this analysis we look at all women in SOEP-data from SOEP v35. We discard observations before 2001 in order to understand current retirement behavior. See section A.3 and section 3.

2.3 Income tax, SSC contributions and unemployment insurance

Our model further includes key features of other elements of the German tax-and transfer system. Income taxation in Germany follows a progressive smooth tax function.Income is further reduced through payment of social security contributions (SSC) for the public health insurance, LTC, unemployment insurance and pension contributions. The contributions total to about 20% of gross earnings. Pensions benefits are also subject to SSC but only for health and LTC insurance. Further, the SSC is capped. The German system distinguished between two kinds of unemployment benefits: After loosing a job, one receives ALGI, which is around 67% of the previous net earnings for approximately 12 months. After that, ALGII comes into play. ALGII Payments are not dependent on previous earnings anymore.[17]

3 Data sets

In this paper we make use of two data sources that both are representative of the same German population: For estimation of the main structural parameters and exogenous care demand we use SHARE.[18] Further, we estimate certain exogenous processes (income processes and health transitions) using SOEP.[19] Both data sets have specific strengths. The main advantage of SHARE is the availability of individual level information on care provided, hours worked, retirement behavior and many socio-economic variables. Among those, we find information on parental health and age which is very valuable information considering the issue at hand. SOEP data on the other hand incorporates richer income information and is a yearly panel with more waves and more observations per wave.[20]

3.1 Construction of data sets

We make use of all German SHARE waves (1-7) including the SHARElife questionaires in waves 3 and wave 7. We construct two data sets using SHARE which each fulfill specific purposes: For the structural estimation, we construct a data set containing all women aged 55 to 68 who give valid responses on all important variables. The final estimation data set contains 5,468 observations on 2,664 women.[21]

Second, we construct the parent-child data set. Starting from all observations in SHARE aged 65

[17]In the model we abstract form ALGI and assume that agents directly fall back to low ALGII payments if they become unemployed.

[18]See Boersch-Supan and Wilke (2004),Börsch-Supan and Malter (2015), Malter and Börsch-Supan (2017) for further information on SHARE

[19]See Goebel et al. (2019) for further information on SOEP data.

[20]For definitions of SOEP variables, see section A.3.

[21]See section A.1 for a description of the main variables in SHARE

and older we use the full information given on all living children of household members (Gender, birth year, Labor market status, distance to parent, frequency of visits to parents, martial status) and expand the data set along the children; we end up with a data set which has at heart the information on each child but contains the full information of parents. This data set then contains 19,963 observations on 3,582 parents.[22] For descriptions on the SOEP data set, see the corresponding sections on the estimation of the wage function (section A.8), non labor income (section A.9), partner income (section A.10), and health transitions (section A.7).

3.2 Summary statistics of SHARE data-estimation data set

Tables 3 and 4 gives summary statistic on the estimation data set. The mean age is 61.52 years and we observe individuals from the years 2004-2017.[23]. 76.2% of the respondents have a partner in the same household. We find that 40.9% are retired, 39.5% are active in the labor market. The mean working hours among the ones active in the labor market is 31.73 hours per week. We find that 8.4% provide some kind of informal care, with 5.4% providing low-intensive informal care and 3% providing high intensive informal care. We do not observe the formal care choice for one's parent in the estimation data-set. Therefore we use the parent-child data set to estimate the probability of formal care usage among elderly dependent on parent as well as child information. We then use this information to impute the formal care choice in the estimation data-set.[24]

Resulting from this imputation, we find that 15.7% of all observed women in the estimation data-set organize formal care for a parent. This proportion differ along age of children as age and health status of parents as well as age of the children evolve. Further, the probability of a parent being alive decreases with age. Therefore the probability of formal care organization peaks at age 58 with 18.21% and decreases from there to 6.4% at age 68 (see Figure 17 in the Appendix, left panel). Conditional on one parent being alive the probability rises monotonically with age of the observed individual, starting at 27% at age 55 and peaking at age 68 with 72.3% (see Figure 17 int the Appendix, right panel).

Table 25 shows that proportions of provided care differ only slightly along labor market status. However, informal care provision is highest among part-time employed women.

4 The behavioral model

In order to assess the policy makers' options to simultaneously react to increased demand for informal care and delay retirement we develop a structural model of informal and formal care provision and female employment. Women make decisions in the ages 55 to 68, are forced to retire and not to provide

[22]See section A.2 for a descriptive Table on the parent-child data set.
[23]The SHARE questionnaire is asked in the years 2004, 2006, 2007, 2011, 2012, 2013, 2015 and 2017.
[24]See section A.4 for further information.

Table 3: Summary statistics of SHARE data- estimation data set

Covariate	Mean	Standard deviation
Age	61.52	(3.962)
High Education	0.350	(0.477)
East Germany	0.189	(0.392)
Number of children	1.476	(1.309)
Work Experience	26.33	(12.07)
Years since retirement	1.706	(3.161)
Married	0.762	(0.426)
Experience in informal care provision	0.306	(0.624)
Mother alive	0.317	(0.466)
Age of mother	84.40	(5.052)
Health of mother	1.839	(0.773)
Father alive	0.110	(0.313)
Age of father	84.31	(4.600)
Health of father	1.874	(0.774)
Parents live close by	0.724	(0.447)
Worked last period	0.448	(0.497)
Death of parent since last period	0.109	(0.311)

This Table shows means and standard deviations of important covariates and variables used in the behavioral model in the main SHARE data set: Women aged 55-68. This data set is used for estimation of the main structural parameters.
Source: SHARE-data, own calculations

any care at age 69 and incorporate utility derived until the end of life at age 80. In each period, agents decide between unemployment, part- and full-time employment and if eligible retirement. Agents who have a least one parent that is alive face the option that a parent needs LTC. Adult daughters can decide whether to provide care informally, either low, or high intensive. Importantly, we also incorporate the decision to organize formal care for a parent into this model. Agents can combine informal and formal care. They make a decision that jointly incorporates utility of the potential care giver and the potential care receiver-a parent. In that way the decisions takes into account utility derived from leisure and consumption directly and utility derived through care provision indirectly. We concentrate on the choice of care providers (a daughter), not on that of a care receiver (a parent).

Agents are restricted in several ways: First, they can only supply labor if they receive a job offer. The probability to receive a job offer is one if the agents has worked in the last period and is decreased after spells of unemployment. As stated, agents can only provide care to a parent if a parent is in need of care. We therefore need to model care demand. This is crucial as caring decisions are taken conditional on perceived demand by parents. Without a proper modelling the care-demand estimates for structural model parameters in connection with formal and informal care might be biased. Agents can only decide to provide care if they face care demand and they can only provide labor hours if they have a job offer and retirement is only possible once women fulfill the eligibility criteria. Further, individuals face time and monetary budget constraints. We model the German tax- and transfer

Table 4: Main choices in SHARE data- estimation data set

Choice	Mean	Standard Deviation
Caring choice (1-3)	1.114	(0.401)
Providing informal care	0.084	(0.277)
Providing low intensive informal care	0.054	(0.227)
Providing high intensive informal care	0.03	(0.171)
Formal care (imputed)	0.157	(0.364)
Working choice (0-2)	0.576	(0.778)
Labor market participation	0.39	(0.489)
Working hours (among labor market participants)	31.73	(12.70)
Retired	0.409	(0.492)

This Table shows means and standard deviations of the choice variables used in the model in the main SHARE data set: Women aged 55-68. This data set is used for estimation of the main structural parameters.
Source: SHARE-data, own calculations

system, incorporating the pension benefit system and the LTC insurance. Agents receive income from labor, spousal income and income from assets. We abstract form savings decisions as the savings profile of individuals in the age range is rather flat. Health transitions of parents and income processes are estimated exogenously and then used in the model. Processes that depend on past and current choices, like job offer rates and transitions of job experience are modelled endogenously.

As standard, individuals make forward looking rational decisions observing current utility of all options and incorporating consequences of these options for the future.

4.1 Choices

In each period agents can make choices between labor supply (no work/part-time/full-time work) and retirement.[25] Due to the exogenous procresses, agents face the risk to be confronted with demand for informal and/or formal care. In periods with care demand agents then have to choose whether to provide informal care themselves (non-intensive/high-intensive care) and/or organize formal care for the care dependent parent or not provide or organize any care. Informal and formal care are modelled as independent. Consequently, agents are faced with six discrete care options once care demand arises: Organize formal care (FC), provide informal care (IC) (either non-intensive informal care (LIC) or intensive informal care(HIC)), combine either LIC or HIC with FC or not provide any care. All combinations between work and care provision are feasible. The outside care option (neither organize formal care nor organize formal care once care demand arises) captures that siblings, the more healthy parent or others organize or provide care to the parent.

Women, who provide informal care choose between 7 hours (low intensive informal care) and 21

[25] Few individuals work after they retire in Germany. In 2018 SOEP data we find that of those individuals who report receiving benefits from the pension system only 5.87% report to be marginally employed.

hours (high intensive informal care) of informal care provision per week.[26]In the model 40 labor hours per week corresponds to the full-time choice, 20 hours a week corresponds the part-time choice. These discrete hours values correspond to the 25% and 75% percentile of weekly labor hours for women in SHARE.

4.2 Flow utility

In each period agents take decisions that lead to immediate utility derived from a random utility function, given in Equation 2. Following Rust (1994) flow utility combines a non-stochastic part with a random component $e_t(d_t)$. Individual utility U_{it} of an agent is derived from consumption C per period, leisure L_t and from care provision.[27] Utility from caring is of interest only, if a parent is in need of care (care demand CD_t). We can therefore separate flow utility U_{it} into two parts: Direct utility from income and leisure (U_{it}^A) and utility from informal (IC_t) and formal (FC_t) care provision (U_{it}^B).

$$U_{it}(s_t, d_t, m, \theta) = U_{it}^A(C_t, L_t, \theta) + U_{it}^B(IC_t, FC_t, \theta) * \mathbb{1}(CD_t > 0) + \epsilon_{ist} \tag{2}$$

Utility[28] from income and leisure (Equation 3) is derived through a trans-log utility function:

$$U_{it}^A(C_t, L_t, \theta) = \theta_C ln(aC_t) + (\theta_{L_m} + \theta_{L_{AGE}}(AGE - 55))ln(bL_t) \tag{3}$$

The utility parameter θ_C defines the curvature of the decreasing marginal utility with consumption while θ_{L_t} gives the curvature of utility derived from leisure by two unobserved types. The unobserved types $m \in \{1, 2\}$ are allowed to differ in their preference for leisure. $\theta_{L_{AGE}}$ incorporates age specific utility from leisure. Age is a proxy for health impacting the taste for free-time.

Utility from care provision, as given in Equation 4 depends on the type of care as well as the unobserved type. Intensive (HIC_t) and non-intensive (LIC_t) informal care give different utility (θ_{LIC_m}

[26]From SOEP data we know that the 25% and 75% percentile in the care hours distribution are 7 and 21 hours per week in a comparative sample. We use these discrete mass-points as discrete choices of non-intensive and intensive informal care. In SHARE, respondents inform about the frequency with which they provide informal care. We use this information to proxy the care provision in the data.

[27]As our model abstracts from savings, yearly consumption equals disposable income Y. While savings are important in inter-temporal decision making in general, the German insurance system covers big parts of old age income and costs from care provision. Income from private savings make up only around 8% of old age income in Germany in 2015 (see BMAS (2021)), while income from the pension system make up around 65% and therefore play the biggest role in retirement decisions in Germany. Also, the savings profile in Germany is such that savings from the age 55 are no longer very important for income in retirement. Further, we do this to keep the model traceable.

[28]We use the OECD equivalence scale and use $a = \frac{1}{(1+0{:}7x)}$, where x represents the number of additional persons in the household. This adjustment reflects economies of scale in consumption and follows e.g. Adda et al. (2017). L_t is normalized by dividing by $b = \frac{1}{4160}$, the maximum amount of hours of leisure available per year.

and θ_{HIC_m}) as does formal care (FC_t, θ_{FC_g} with $g \in \{1, 2\}$). If a combination of formal and informal care is chosen, the combined utility parameters from informal and formal care are impacted by the parameter θ_{CC}. We let the caring parameters vary by unobserved types $m \in \{1, 2\}$ to allow for differing preferences for caring.

$$U_{it}^{B}(IC_t, FC_t, \theta) = \theta_{LIC_m} LIC_t + \theta_{HIC_m} HIC_t + \theta_{FC_m} FC_t + \theta_{CC}(IC_t \& FC_t) \tag{4}$$

Whether utility from providing informal and/or formal care is positive or negative is unambiguous. On the one hand providing care can be burdensome physically, especially as we deal with individuals aged 55 and above.[29] This would lead to negative utility from providing informal care. On the other hand, one might feel obliged to provide informal care for a frail parent, which would correspond with altruistic motives (Johnson and Sasso (2000)). Formal care organization can in the same way lead to positive and negative utility. From an altruistic perspective, one might feel relief that the parent is being taken care of in a professional way. However, one might feel guilt that care is not being provided by oneself (Li et al., 2010; Mommaerts, 2015). If utility from both informal and formal care are positive, altruistic motives might lead to higher utility parameters from informal than formal care due to preferences of parents to be cared for by their children (HCHE, 2017). The same is true for the parameter θ_{CC} on the combination of informal and formal care. This parameter incorporates the fact that formal care takes away part of the burden of informal care provision in that option. On the other side, the combination of informal and formal care can create an extra amount of organization. The parameter θ_{CC} can therefore be positive of negative. Other motives to provide informal care can be monetary benefits through the LTC system or forgone formal care costs.

The vector of parameters to be estimated is θ; $s_t \in S$ contains state variables which affect individual decisions in each period t, and S represents the state space of all feasible realizations of the state variables.[30] $d_t \in D(s_t)$ represents the decision made by the individual from a set of different feasible actions $D(s_t)$ in period t. The choice, state in individual specific error term ϵ_{ist} can be interpreted as an unobserved state variable (e.g. Rust (1994); Rust and Phelan (1997), Aguirregabiria and Mira (2010)).

Heterogeneity in utility comes from several sources: We implement preference heterogeneity in the utility of leisure by assuming two unobserved types $m \in \{1, 2\}$ which comprise a fixed proportion of the population (Heckman and Singer, 1984). We also allow the preferences of informal and formal care to differ by the same groups. By modeling the probability of belonging to type m as a function of the employment history at the initial age, we also account for non-random initial conditions (Wooldridge, 2005). For further details on the initial conditions, see section A.13. Further, agents differ in their

[29]Bom et al. (2019) among others discusses direct and indirect health effects of care-giving for the care-giver.
[30]See section A.11 for a list of all variables carried in the state space.

education level, work experience, the existence of a partner and years spend in retirement. These aspects lead to differences in income through the income processes (see section 4.6). Education, further, is a proxy for wealth accumulated by parents and children.

4.3 Budget Constraints

Agent's decisions are subject to a time budget constraint as given in Equation 5. Individuals have 80 hours of leisure per week by default which is reduced by their time spend in employment (part-time or full-time) or informal care provision (high intensive or low intensive; see equation 5). Formal care, retirement and unemployment do not reduce leisure time.

$$L_t = L_{max} - IC_t - H_t \tag{5}$$

Consumption C is derived from gainful employment ($H_t * w_t$), non-labor income (A_t), income of the spouse (SI_t), pension benefits if retirement is chosen (PB_t), unemployment benefits if unemployment is chosen when retirement is no option yet (UB_t), cash benefits from informal care provision if informal care is chosen (CB_t). Individuals pay taxes (Tax_t), pay social security contributions (SSC_t) (see Equation 6). Income per period is reduced by tax payments, social security contributions and potential costs of formal care organisation. Apart from labor income, non labor income and spousal income, we calculate the components using a full simulation of the German Tax and transfer system. The hours choice H_t and the hourly wage w_t define labor income. Hourly wages depends on labor market experience and education. Spousal and non-labor income depend on the existence of a spouse, own education and age.

$$\begin{aligned} C_t =& H_t w_t + A_t + SI_t + IH_t + \mathbb{1}(R_t = 1)PB_t + \mathbb{1}(R_t = H_t = 0)UB_t + \\ & SA_t - Tax_t - SSC_t + \mathbb{1}(C_t > 0)CB_t \end{aligned} \tag{6}$$

Our model also incorporates the fact that dependent on the care dependency status of a parent, the several caring option impact the budget differently. As pointed out in Section 2 and Table 1, benefits from the LTCS are neither earmarked nor means-tested but depend on the care dependency level of the respective benefit receiver (here: the parent). Individuals in the model receive benefits only if the care dependent parent is expected to be eligible for pension benefits. Using information on health and age, we predict the number of limitations with ADL (see section A.5.). If at least 2 limitations with ADL and one limitation with IADL are expected, individuals receive 316 Euro in cash benefits per month. We imply that the care depended person needs at least the minimum criteria of care, amounting to 90 minutes per day for care level 2. In the non-intensive care option individuals provide 30.1 hours of care per month, 67% of the needed care and are reimbursed with 67% of the respective benefits. In intensive care, the care-giver provides 90.3 hours of informal care per month. If the care dependent person is predicted to be in care level 2, less time than 90.3 hours is required. Therefore, only the highest amounts of benefits in care level 2 are granted (316 Euro in 2020). If higher care levels are predicted, benefits in intensive care are increased, while in non-intensive care, amounts stay constant.

Accordingly, agents face costs connected with the organization of formal care. Even though the LTCS offers benefits for formal care (see section 2), often individuals have to pay parts of the costs out of their own pockets. In this case, later inheritances are reduced. In some cases, children partly help financing the care needs of parents. In the model, we assume lump-sum costs of formal care organisations that depend on care-dependency. Costs for formal care are in the model follow the pattern from the SHARE data (see Section 2.1). If a combination of formal and informal care is chosen, costs rise as the benefits are reduced accordingly. The German LTC system offers the opportunity to collect pension points in times of care provision if individuals work less than full-time and are not yet retired. This can later be important for the calculation of pension benefits as half a pension point collected can increase benefits by the equivalent of more than one year of part-time work for many women. We include this important dynamic incentive in our model.

4.4 Care demand

Care provision or organisation of formal care is only possible if care demand exists. The care dependent person is a parent. Depending on the states, agents are faced with no care demand (if no parent is alive) or a continuous probability that demand for informal and(or formal care is necessary for their parents. As outlined above, formal and informal care are utilized in different circumstances. While elderly parents in relatively good health often still get some informal help from children or other people, elderly parents in bad health often require some additional formal help. Therefore, we separate the formal and informal care decision and accordingly also include separate care demand probabilities for informal and formal help.

Both demand functions depend on health and age of both parents as well as on martial status (of the parent), distance to parents and existence of siblings. We estimate these functions outside the model using the child-parent SHARE data set on different outcome variables, though. In this way, the inputs into the function impact demand for formal and informal care differently. The outcome variable for informal care demand is the usage of informal care (except informal care from the spouse) in the household of the parent. For formal care demand we use usage of any kind of formal care in the parent's household. In order to account for care demand to differ by marital status of the parent we estimate the regression separately on three groups: Mothers who have no partner, fathers who have no partner and parents who are married and live together. The regression equations do not incorporate the existence of a sibling or distance to a parent in the equation. We use predicted probabilities of care-demand in a second step and estimate the impact of distance to parents and existence of siblings on the probability that any given child provides informal care or organizes formal care for their parents.[31]

$$\begin{aligned} P(CD_{t,formal}) &= P(health_{father}, health_{mother}, age_{father}, age_{mother}, sibl_t, pdist_t, mar_t) \\ P(CD_{t,informal}) &= P(health_{father}, health_{mother}, age_{father}, age_{mother}, sibl_t, pdist_t, mar_t) \end{aligned} \tag{7}$$

4.5 Job offer

Individuals can only work on the labor market if they receive a job offer. In our model, retirement is an absorbing state, meaning that no job offers are possible once retirement is chosen. Agents who worked in the previous period have a job offer probability of 1. Agents who chose unemployment previously get a job offer with a continuous probability between 0 and 1. Following Korfhage (2019) job offer rates after unemployment depend on education, unobserved type and age. Individuals above the legal retirement age of 65 have a reduced job offer probability.[32]

4.6 Further processes

In this Section we describe how further important processes are modelled. The evolution of years of work experience and care experience is important for the wage process and the collection of pension points in times of informal care supply. Transitions of health of parents is important as this drives agents' expectations of demand for care. Income processes define income from various sources.

Work and Care Experience

In our model, some variables evolve independently from agent's choices. Among them are mother and father's age, parental health and survival and the own age. Some factors are constant throughout the model: education, type, distance to parents and existence of siblings. Some evolve deterministically with decisions of the agents: work experience, care years, years in retirement. Part time employment in the current period increases work experience by 0.5 while full-time employment increases work experience by one whole year. The number of care years provided increases only with informal care provision; by 1 year through intensive care provision and 0.5 through non-intensive care provision.

[31] See section A.6 for regression equations and results.

[32] The job offer probability after unemployment is estimated following this equation 8.

$$P(JO_t = 1 | H_{t-1} = 0 \& R_{t-1} = 0) = \frac{exp(\lambda Z_{t-1})}{1 + exp(\lambda Z_{t-1})} \tag{8}$$

Parameters λ are calibrated using estimates from Korfhage (2019). The following equation defines the job offer rates:

$$Z_t = -1.3927 - 0.1704\mathbb{1}(Age >= 65) + 0.2916 Educ + 0.5263 Type_2 \tag{9}$$

Health Transitions and Survival Rates of Parents

Parental health follows a function depending on current health, age and gender of the parent. Agents form believes about the future health which follow the observed transitions, estimated on SOEP data.[33] Children, therefore, have perfect understanding of the health processes and survival rates of their parents. Future health of parents is important for agents as it defines the possibility to face care demand which has impacts on the potential to keep on working and/or retire. However, future health of parents is not impacted by current choices. We do not let health transitions be endogenously dependent on the type of long term care because LTC, as Mommaerts (2015) points out is not meant to impact health but is meant to uphold the ability to perform basic personal tasks. This is also in line with Applebaum et al. (1988), Card et al. (2008) and Finkelstein and McKnight (2008) finding no effect of the type of LTC on mortality or health transitions in later life.

Survival rates are taken from official statistical life tables provided by European Statistics (Eurostat)[34]. Survival in this way does not depend on the type of care or the health status. It only depends on gender and age.

Income Processes

Each period agents observe their income in all possible choices depending on the realized state variables. These are important for flow utility. Wages, non-labor income and spousal income follow a functional form which is estimated outside the model using SOEP data. Income from different aspects of the social security system are calculated as outlined above.

The wage is determined by human capital which is approximated by work experience, level of education and age (see section A.8). If a person is married, potential income from a spouse increases household income, dependent on education and age of the agent (see Section A.10). The last part of household income is non-labor income. This can contain e.g. assets, rental, and private retirement insurance income. Non-labor income depends on education, the existence of a spouse and age (see Section A.9).

4.7 Solution of the model

Each period agents observe their state vector s_t and make choices d_t that maximize their expected discounted lifetime utility given by Equation 10. Agents take into account the future which they discount with the factor β and additionally they take into account their age specific survival probability p_t. According to Bellman's principle of optimality agents take into account only today's (t) flow utility and tomorrows $(t+1)$ expected discounted utility (Bellman, 1957). According to Rust (1987) if we assume that the utility function is additively separable in observable and unobservable components, the ele-

[33]See section A.7 for details on the estimation and results.

[34]See http://ec.europa.eu/eurostat/data/database.

ments in the error ϵ_t are conditionally independent so that $F(s_{t+1}, \epsilon_{t+1}|d_t, s_t, \epsilon_t) = G_\epsilon(\epsilon_{t+1})F_s(d_t, S_t)$ and have an extreme value type 1 distribution agent's value function has the closed form solution given in Equation 11. We can solve this by backward induction, so $p_t()$ is a Markov transition probability function representing agent's beliefs about future states. λ and ψ represent the parameters in the job offer and care demand probabilities that we set. Following, we can calculate choice probabilities for feasible choices d_t as given in Equation 12. $d_t^{'}$ represents the other feasible choices.

$$\underset{d_t \in D(s_t)}{max} E_d \left\{ \sum_{j=t}^{T} \rho_t \beta^{j-t} u_j(s_j, d_j, \epsilon_j)|d_t, s_t, m, \epsilon_t \right\} \tag{10}$$

$$\begin{aligned} &v_t(s_t, d_t, m, \theta, \lambda, \psi) = u_t(s_t, d_t, \theta) + \\ &\rho_t \beta \sum_{(s_{t+1})} log \left[\sum_{d_{t+1} \in D(s_t+1)} exp\{v_{t+1}(s_{t+1}, d_{t+1}, m, \theta)\} \right] p_t(s_{t+1}|s_t, d_t, \lambda, \psi) \end{aligned} \tag{11}$$

$$P(d_t|s_t, m, \theta, \lambda, \psi) = \frac{exp\{v_t(s_t, d_t, m, \theta, \lambda, \psi)\}}{\sum_{d_t' \in D(s_t)} exp\{v_t(s_t, d_t', m, \theta, \lambda, \psi)\}'} \tag{12}$$

The discount factor β is not estimated but defined as 0.98 which is in line with the literature (see e.g. Cooley and Prescott (2021)).

4.8 Estimation of structural parameters

We estimate the model applying a maximum likelihood estimation approach comparable to the ones formulated in Rust (1994) and Rust and Phelan (1997). Our approach diverges from theirs as we do not observe job offers and care demand in the data. While Korfhage (2019) estimates both variables inside the likelihood function exploiting variation in the observed data we take parameters for both functions from exogenous estimations (see above). Applying an approach similar to the one in Iskhakov (2010) we use the probability functions in Equations 8 and 7 to integrate over the unobservables. Hence, the likelihood incorporates the probability distribution of $\{JO, CD\}$ and takes the following form:

$$L(\theta, \lambda, \psi, \alpha) = \prod_{i=1}^{I} \left[\sum_m P(m|s^i_{T^i_0 - 1}, \alpha) \prod_{t=T^i_0}^{T^i} \sum_{jo,cd} q_t(jo, cd|s^i_{t-1}, d^i_{t-1}, \lambda, \psi) P(d^i_t|s^i_t, m, \theta) \right] \tag{13}$$

$P(d_t)$ represents the choice probabilities (12) which are derived in the dynamic model. q_t is the probability of being in any state of (jo), which is derived from functions (7) and (8). As individuals are observed for different time spans, T^i_0 indicates the first observation period and T^i her last observation per individual. $P(m)$ represents the agent's probability to be in one of the two unobserved types m. In this way we let women differ permanently in their taste for free-time due to unobserved variables. These unobserved variables are correlated to observed initial conditions. T_0^i indicates the first observation per individual as observed in SHARE data, T^i the last. The parameter vector $\{\theta, \alpha\}$ will be estimated within the ML estimation, the parameters for λ and ψ come from exogenous estimations.[35]

5 Results

Table 5 presents structural model parameters as estimated in the maximum likelihood estimation.[36][37] The structural parameters are all of the expected size and direction. Agents experience positive

Table 5: Structural model parameter estimation results

Description	Parameter	Coefficient	Standard Error
Consumption	θ_Y	2.40	0.01
Leisure hours (type 1)	θ_{L1}	0.78	0.01
Leisure hours (type 2)	θ_{L2}	4.54	0.01
Leisure age trend	$\theta_{L_{AGE}}$	0.36	0.01
Light informal care (type1)	θ_{C1}	1.92	0.02
Intensive informal care (type1)	θ_{C2}	2.46	0.02
Formal care (type1)	$\theta_{C_{FC}}$	2.89	0.01
Light informal care (type 2)	θ_{C1}	2.06	0.04
Intensive informal care (type 2)	θ_{C2}	1.82	0.07
Formal care (type 2)	$\theta_{C_{FC}}$	0.18	0.01
Combination care	θ_{CC}	-1.33	0.02

This Table shows results for the main utility parameters as estimated using Maximum-Likelihood estimation.
Source: SHARE data, own calculations

marginal utility from consumption. Further, utility from leisure depends on one's own age and type. Leisure yields positive utility for all individuals. Leisure becomes increasingly valuable with age, according to the result on $\Theta_{L_{Age}}$. Therefore, as age increases, so does disutility of labor and time spend in informal care provision. Utility from care-giving depends on the combination of formal and informal care and also on the interaction with utility from income (through benefits) and leisure (time spent in informal care). The direct utility from care can be seen in Table 6. We find altruistic utility from only providing informal care which is lower than if formal care is included. High intensive informal care always yields higher altruistic utility than low intensity informal care. In contrast to estimates

[35]See sections 4.5 and 4.4. For more information on the estimation, see Appendix Section A.12
[36]Estimates for the probability to belong to one of the two unobserved latent types is given in Table 23 in the Appendix
[37]Estimation results of the exogenous processes are presented in the Appendices.

Table 6: Utility from formal and informal care

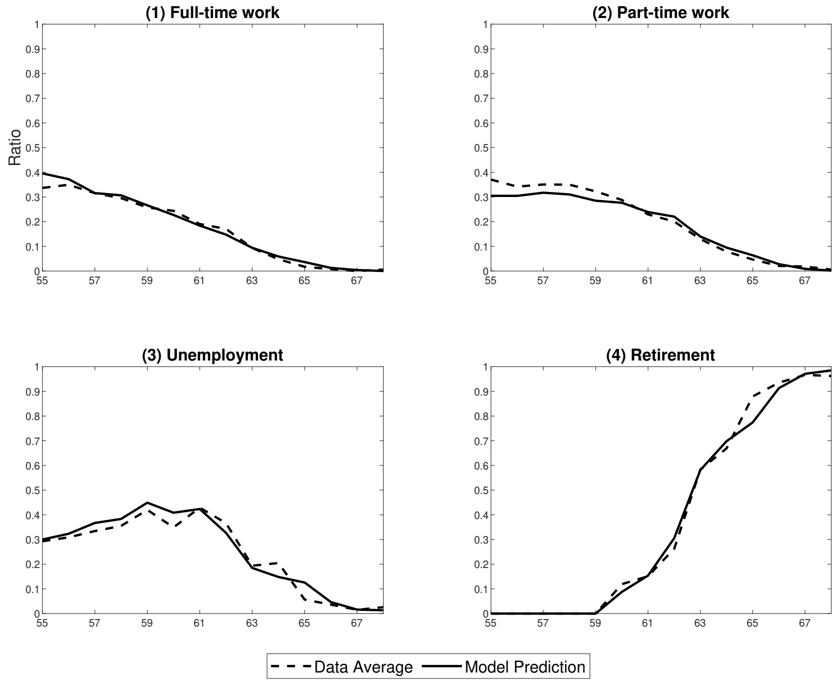
	Type 1		Type 2	
	No formal care	Formal care	No formal care	Formal care
No informal care	0	2.89	0	0.18
Low intensive informal care	1.92	3.48	2.06	0.91
High intensive informal care	2.46	4.02	1.82	0.67

This Table shows direct utility derived by women of the two heterogeneous types by informal and formal care provision. The numbers do not include utility from leisure or consumption.
Source: SHARE data, own calculations

from (Korfhage, 2019) and (Skira, 2015) we find positive utility from providing informal care. There are several reasons why this difference occurs. First, we include exogenous processes for care demand and therefore model care demand more accurately. Second, in constrast to Korfhage (2019), we include levels of informal and formal care benefits and costs that differ by care dependency of parents. This impacts the opportunity costs of caring. Further, we find that women of unobserved type 1 have lower utility from leisure and they receive more utility from providing high intensive informal care. Further, utility gains from formal care organization are higher for women of type 1 than type 2. Figure 2 shows the fit of the model in key outcomes with respect to labor market choices and retirement by age and educational status. To compare data averages and model predictions, a data set was constructed using the dynamic model and utility parameters as described above. To ensure comparability with the original data, decisions are simulated for all observations only for the states (e.g. age, education etc.) in which they are observed in the data. Figure 2 depicts means of labor market choices by age in the data (dotted line) and simulation (solid line). The model fits the labor outcomes and retirement decisions of the data well. Our model correctly simulates the relationship between part- and full-time work by age where full-time work shows a starker decline with age in both, data and simulation. Our model also matches the development of unemployment. Women first show increased unemployment percentages before they can retire and unemployment rates fall drastically. Retirement behavior is also matches. Few individuals in the data can retire before age 63. Our model matches the fact that retirement proportions increase dramatically from age 63 onward. Nearly all women are retired by age 68 in the data and simulation alike. To understand caring choices, Table 7 shows portions of all possible caring choices among those with at least one living parent in the data and the simulated data. Overall, the model is able to fit the broad picture of care provision well. We see a light over-prediction of caring, especially of low intensive informal care without formal care. The prediction of formal care is overall very good, if slightly too high.[38]

[38]Figure 22 in the Appendix depicts provision of formal and informal care by in the overall sample. We depict the model fit of caring decisions by age and age and education in figures 18 and 19.

Figure 2: Model fit: labor supply and retirement decisions by age



Further, the model fits the main transition probabilities in work status and care provision.[39] The model matches high persistence of non-employment well, while it lightly over-predicts transitions from employment into non-employment and vice versa. The same holds for informal care-giving. The model, however over-predicts the transitions from formal care-giving to formal non-care-giving and under-predicts the persistence in formal care-giving.

5.1 Effects of an increase in female labor force participation

In this section we show how an hypothetical increase in female labor force participation impacts employment and caring behavior in the model. Firstly, this exercise helps us to understand the dynamics of the model and we can estimate baseline elasticities for caring behavior with changes in labor market outcomes. Secondly, as female labor supply is expected to increase in the future in all age groups irrespective of retirement rules this exercise is helpful to understand issues for policy makers.

We simulate behavior of individuals as observed in the data in the age 55 until the end of the model period (age 68). First, we do this for all individuals observed at age 55 given the current states and reported labor market participation- the baseline simulation.Then, we do the same exercises but

[39]Table 26 in the Appendix summarizes the transitions in observed and simulated data.

Table 7: Care provision in data and model predictions

	Data average	Model prediction
No formal care		
No informal care	52.29%	48.07%
Low intensive informal care	9.62%	15.52%
High intensive informal care	4.15%	3.87%
Formal care		
No informal care	22.22%	25.03%
Low intensive informal care	6.80%	4.55%
High intensive informal care	4.92%	2.97%

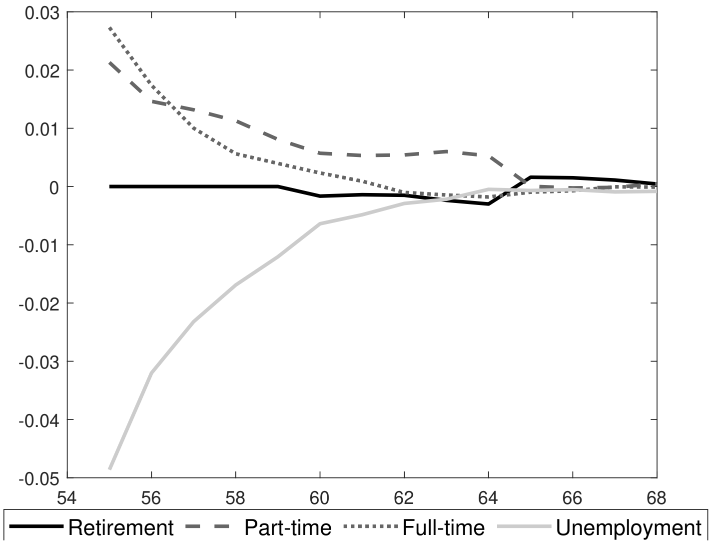
This Table shows proportions of care provision (combination of informal and formal) as observed in the main estimation data set and as simulated by the behavioral model.
Sourse: SHARE-data, own calculations

artificially increase labor force participation of women at age 54 from currently 74.09% to 81.54% (a 10% or 7.45pp increase in labor force participation).[40] Figure 3 depicts labor market responses by age and education. The solid black lines depict differences in the probability to be retired by age between baseline and scenario. The solid grey line shows differences in part-time employment while the dotted grey lines show reactions in full-time employment. The light line shows unemployment differences. We find that at age 55, as 7.45pp (10%) more women are active in the labor market at age 54, labor force participation rises by 4.87pp (16.65%) with an increase by 2.31pp (6.89%) in part-time employment and 2.73pp (6.85%) increase in full-time employment. We find an immediate response in care provision: A shift from high intensity informal care (0.47pp or 5.67% decrease) to low intensity informal care (0.3pp or 2.71% increase) and a decrease in formal care (-0.24pp or -1.41%). Overall at age 55, we find a decrease in informal care given (0.11pp or 0.12%). Figure 3 shows that employment responses slowly die off with increasing age. At age 57, we find a 2.32pp increase in employment and at age 60 a 0.8pp increase. Retirement is slightly delayed, with an increase in the mean retirement age by 0.0058 years. Naturally, responses are higher for lower educated women, as higher educated women show high employment rates at age 54 anyways.

We find that high intensity informal care is decreased in all ages, while light IC is slightly increased until age 57 but then decreased in later ages (see Figure 23) in the Appendix. Formal care is in slightly lower demand. Interestingly, more formal care is demanded in higher ages as people receive higher pension benefits and work longer. Over the full life cycle we find a 1.13pp (1.89%) increase in employment, a 0.07 (0.91%) decrease in low intensive IC, a 0.19pp (9.0%) decrease in high intensive

[40] For both simulations, the value function iteration is the same. The dynamic programming is not altered between the scenarios.

Figure 3: Effects of a 10% increase in female labor force participation at age 54 on employment



IC and a 0.26pp (2.01%) decrease in FC demand. All in all, we find a 13.5% decrease in labor hours and a 0.55% decrease in hours spend in IC. The amount of women who face a double burden of work and IC provision is increased by 0.63pp at age 55.

As we perform the opposite exercise (a 10pp decrease in female labor force participation at age 54) patterns are reversed. As labor hours are decreased by 2.61%, IC hours are increased by 0.07%. The model is therefore able to capture the time conflict between paid employment and informal care provision. We see that while women shift from high intensive to low intensive informal care, the overall amount of informal care provided is impacted less. As this is the first model to incorporate formal care choices it is of great interest to understand the dynamic responses in FC demand. In this scenario, formal care demand does not rise as informal care giving decreases. This could partly appear as costs for formal care play a role. Further, we model demand for formal and informal care independently. Formal care is no perfect substitute for informal care.

5.2 Validation: Effects of the abolishment of women's pension

In this section we show dynamic effects of abolishing women's pension applying the dynamic model. As mentioned above (Section 2), German women born until 1951 could retire early at age 60 if they fulfilled certain criteria.[41] This possibility was abolished in the 1999 pension reform. Women born from 1952 onward can only retire early at age 63. Geyer and Welteke (2021) and Geyer, Haan, et al. (2020) show

[41] In the model we abstract from the eligibility criteria for women's pension.

that this reform leads to an increase in labor market participation at ages 60-62 for women born just above the cut-off compared to those born before. They also show increases in unemployment. Fischer and Müller (2020) use this reform to show decreased informal care activities for the women affected by the reform. We do not use this variation in the data for identification of structural parameters. This exercise is therefore interesting not only to show effects of increased retirement ages on caring behavior itself. It also shows that the model is able to simulate effects of policy changes that already took place but that are not directly contributing to identification.

In our sample of women aged 55, only 16.95% are born before 1952. As we only use women aged 55 for simulations, we go about as follows: We first simulate behavior for women aged 55 until age 68 pretending that all women are born before 1952 and treat outcomes as the baseline behavior. Then, we pretend all women are born from 1952 onward and repeat the simulation. This will be the simulation data-set. We then compare behavior in these two groups.

Table 8 compares parameters from reduced form evidence to the analogous parameters resulting from the simulation. Column 1 shows mean differences between women born in 1951 and those born in 1952 while column 2 shows regression discontinuity (RDD) effects from literature.[42] Columns 3-5 give information on the specification from the parameters obtained in reduced form literature. We find that retirement and employment effects are similar to those from Geyer and Welteke (2021). We can not differentiate between unemployment and inactivity in the model. Therefore we report the combined non-employment effect. This effect is slightly bigger than in the literature. We find a reduction in the probability to be a carer by 7.2 percentage points (pp), which is 1.4 pp higher effect than in Fischer and Müller (2020). Our estimate on intensive care provision is very close to that of Fischer and Müller (2020). We find a reduction in care hours per month of 3.856 hours, which is an approximate 0.12 hours per day effect.[43] Literature finds a slightly smaller effect. All in all, our model matches the reduced form estimates very well.

Reduced form evidence could not investigate impacts on demand for formal care. In the simulation, formal care organization increases by 3.38pp (25.1%). Further, we can use the model to show how employment responses to the reform differ by care-demand: We compare women with at least one parent alive at age 55 with those, who have no parent who is still alive. Women with care demand have a higher probability to go into part-time work or unemployment as they can no longer retire at age 60. Among women with care-demand the probability to work full-time at age 60 rises by 15.91pp while it rises by 8.49pp for women without care-demand.

[42] In the model we do not track birth month. Therefore, we can not include birth cohort trends in the estimation and do not claim to estimate a RDD in the model. We simply compare differences in mean outcomes between the birth cohorts in the group of women born in the two years and ages 60-63.

[43] In the model we do not differentiate between weekdays and days on week-ends; Fischer and Müller (2020) estimate hours effects for time spent on weekdays.

Table 8: Validation: Comparison of parameters from model prediction and reduced form evidence

	(1)	(2)	(3)	(4)	(5)
	Model	Reduced form	Source	BW	Control Variables
Retirement	-0.299***	-0.276*** (0.02)	G&W	12 months	YES
Employment	0.135***	0.135*** (0.04)	G&W	12 months	YES
Non-employment	0.165***	-	-	-	-
Unemployment	-	0.052*** (0.01)	G&W	12 months	YES
Inactivity	-	0.062*** (0.01)	G&W	12 months	YES
Caring	-0.072***	-0.058** (0.02)	F&M	24 months	Age, year
Hours of care	-3.856***	-0.073 (0.10)	F&M	24 months	Age, year
Int. Care	-0.028***	-0.023 (0.02)	F&M	24 months	Age, year

This Table shows parameters from regression discontinuity regression using the 1999 pension reform for German women from literature and the model prediction. We look at women aged 60-62.

Source SHARE, own calculations

G&W: Geyer and Welteke (2021); F&M: Fischer and Müller (2020);YES: month fixed effects, income group, having children, and western Germany dummies, and linear trends in the running variable (month of birth) on both sides of the policy cutoff; Int. Care: Intensive care

6 Policy simulations

In this section, we show results of simulated potential future policy changes. One important advantage of estimating structural dynamic models it that we uncover the underlying behavioral parameters and use them to asses efficiency of potential policy reforms. We first perform simulations in which we alter the retirement system and look at impacts on employment and caring behavior. This reform is of great policy relevance as women born from 1964 onward face a NRA at age 67 onward. Our simulation can show side-effects of this reform. Then, we investigate the role of dynamic incentives of the LTC system in caring and employment decisions and combine them with changes to the retirement system. The LTC system is in place to alleviate negative impacts of possible dependency on care and increase provision of informal care. Our simulations help to understand the effectiveness of these policies and understand its mechanisms.

For each simulation scenario we create a new data set using the dynamic model employing the estimated parameters. First, we solve the model for each individual in the model in the baseline starting from age 55. States and choices in the following ages follow from the predictions from the model. Then, we change parameters and simulate the choices and states for the same set of individuals.

6.1 Effects of increased retirement ages

In this section we show effect of changes to the pension system on employment and caring choices. We compare the status quo baseline with a scenario in which the early retirement age (ERA) is set to age 65 and the NRA is at age 67 (scenario 1). This scenario is of interest as in Germany the NRA will be at age 67 for birth cohorts 1964 and thereafter; women will face this new NRA first in the year 2031. We first present behavioral responses by sub-groups before we analyze impacts on income and well-being.

All women experience an increase in the NRA to 67 and an increase in the ERA to 65. Agents understand this from age 55 on and can adjust behavior before the actual change in legislature impacts them (at ages in which they could formerly retire). At the ages in which the impact occurs agents face a decrease in non-employment income. For those with care-demand this reduction in non-employment income at higher ages increases the opportunity costs of time spent in informal care provision. Also, if the knowledge on a later retirement age increases the utility of working in lower ages, the opportunity costs of informal care provision increases in these ages. The effects for formal care are not clear ex-ante. First, costs of formal care are an important aspect. If higher retirement ages lead to a decrease of income (e.g. in higher ages or also in life-time income for those without a job-offer), then, due to the concave utility in income formal care becomes more costly. The opposite occurs if the change in legislature increases income due to an increase in labor supply. This might therefore differ by income groups.

Figure 4: Responses to increased retirement ages

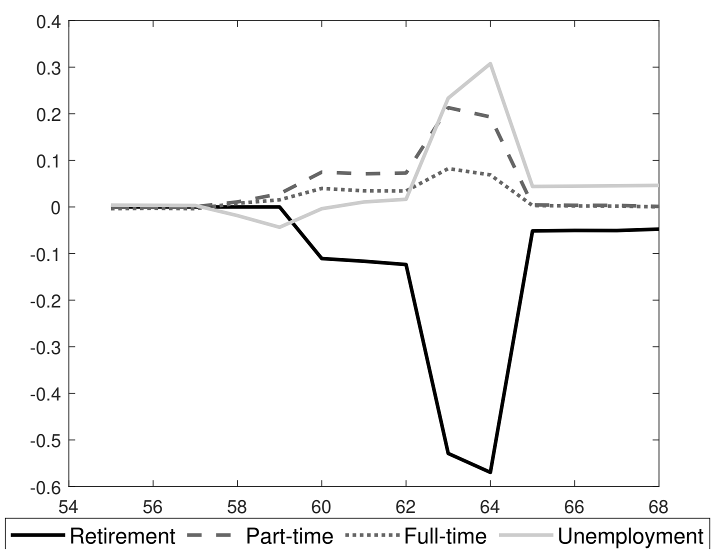
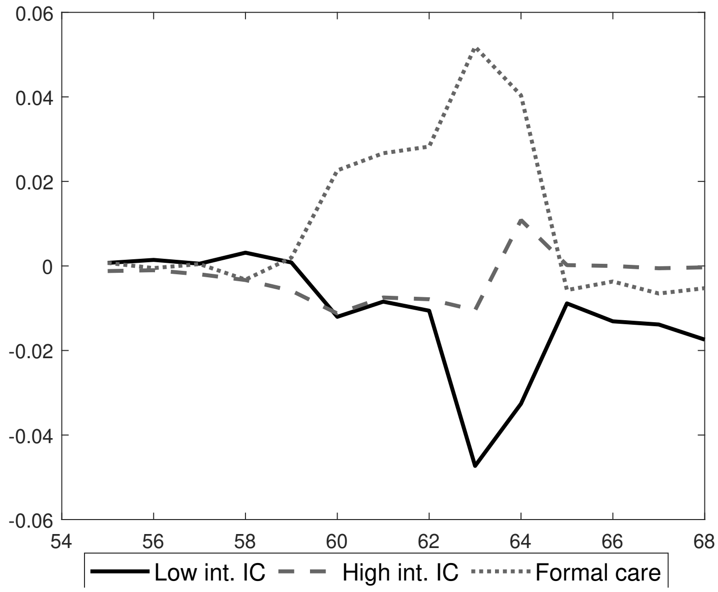


Figure 4 shows average responses in employment decisions by age. Main retirement responses are shown in solid black lines; as the retirement ages are shifted to ages 65 and 67, individuals mechanically delay retirement. Women react by increasing full- as well as part-time employment and unemployment. We find that employment responses are highest at age 63 with a 21.31pp increase in part-time employment, a 8.23pp increase in full-time employment. Unemployment increases by 23.35pp at age 63 and peaks at age 64 with a 30.8pp increase compared to the baseline. The model therefore predicts that 56% of the women that can no longer retire are employed at age 63 while 44.2% go into unemployment. Employment effects differ by education: Lower educated women show a 49.3pp reduction in retirement at age 63, 44.19% of which go into unemployment, 39.78% shift into part-time and 16.01% into full-time; for highly educated women the relation is: 58.82pp reduction in retirement, 44.07% into unemployment, 40.9% into part-time and 14.98% into full-time. The model does not incorporate that leisure preferences might follow a shift in social norms as official retirement ages are increased. Also, labor market opportunities for women in the respective age groups might be better. In reality, employment responses might be bigger. The model predicts anticipation effects in employment. Agents seem to react to longer work horizons by increasing employment before retirement ages. At age 59, full time employment is increased by 1.53pp, part-time employment by 2.83pp and unemployment decreased by 4.36pp. Overall, we find a 15.66% increase in hours worked, and while female labor force participation increases by 6.84% at age 59, it increases by 114% at age 63.

Further, we can investigate employment responses by potential care-demand. Care-demand here is defined as having at least one living parent at age 55. Women with care-demand go into retirement faster in the baseline. In the simulation, at age 64, women with care-demand increase part-time employment by 26.6pp (116%) and women without care-demand by 16.46 (153%), full-time employment at age 64 increases by 3.62pp (160%) for women with care-demand and by 8.15pp (93.7%) for women without care-demand. Unemployment increases by 29.67pp (129%) for women without care-demand and by 33.55pp (203%) for women with care-demand. We therefore find that women with care-demand have overall similar increases in labor force participation but show lower increases in hours worked. This might be due to higher opportunity costs of working when women have to think about providing informal care to a parent.

Figure 5 shows reactions in informal and formal care provision due to the changes in retirement ages. It is interesting to see, that reactions occur in anticipation of later retirement ages also before agents are impacted directly. Further, we see that while low intensive informal care is decreased parallel to retirement responses from age 60 onward and stays negative throughout the ages, high intensive care decreases also in ages before retirement is an option and returns to pre-reform levels from age 64 onward. Formal care organization increases from age 60 onward and reactions return to 0 from age 64 onward. Overall, the sum of provided informal care hours is decreased by about 5.12%. Low intensive IC decreases by 0.9% and high intensive IC decreases by 6.72% before age 62. Formal care provision

Figure 5: Caring responses to increased retirement ages



stays constant before age 62. After age 62, high intensive IC decreases by 3.67% and low intensive IC decreases by 8.9%. The model captures counteracting incentives. While time in retirement is reduced, pension points that can be collected in IC times are less valuable. Further, time-conflicts are increased. On the one hand, in times of unemployment, benefits from IC provision is worth relatively more than in retirement. This isthe reason why we find a small increase in high intensive IC at age 64, where unemployment increases are biggest.

Due to the increases in labor supply and partly low intensity informal care provision, we find that more women face a double burden of informal care and labor supply. We find an increase by about 0.9 pp at age 63. While in the baseline around 2.56% of women work and provide informal care at the same time, it is 2.58% after the introduction of the reform, a 0.78% increase. The double burden can have detrimental health effects for these women.

Income and pension benefits are of course directly impacted by this reform. Our model calculates pension benefits collected until age 80, therefore individuals collect pension benefits for a shorter time horizon due to the reform. On the other hand, individuals who work longer and gather more pension points, experience higher pension benefits per period. We do not compensate agents for lost pension benefits. In that sense our pension reform leads to a surplus in the pension insurance system. Income from labor increases as women work more. Table 9 shows impacts on the net-present value (NPV) of labor earnings, pension benefits and total earnings by income quartile, and the existence of a parent at age 55. Earnings and retirement benefits are calculated until the terminal age 80 and discounted by

Table 9: Response in lifetime earnings to increased retirement ages

	(1)	(2)	(3)	(4)	(5)	(6)
	Euro (All)	% (all)	Euro (CD)	% (CD)	Euro (NCD)	% (NCD)
	in 1000		in 1000		in 1000	
			Δ NPV of labor earnings			
total	120	14.80	121	14.94	119	14.60
1st quartile	106	7.34	118	7.39	86	7.25
2nd quartile	114	31.37	107	32.37	123	30.09
3rd quartile	122	18.47	121	19.15	124	17.67
4th quartile	139	17.77	136	18.19	145	17.01
			Δ NPV of Retirement benefit			
total	-729	-3.99	-752	-3.93	-694	-4.07
1st quartile	-359	-8.68	-393	-8.18	-304	-9.59
2nd quartile	-913	-4.70	-924	-4.68	-898	-4.72
3rd quartile	-745	-3.42	-778	-3.40	-704	-3.45
4th quartile	-900	-3.24	-9125	-3.23	-877	-3.26
			Δ NPV of total earnings			
total	-1.88e+05	-0.97	-200	-0.96	-170	-0.98
1st quartile	-191	-3.32	-197	-3.23	-181	-3.46
2nd quartile	-202	-1.00	-210	-1.00	-190	-1.00
3rd quartile	-152	-0.67	-171	-0.67	-129	-0.67
4th quartile	-209	-0.72	-219	-0.72	-187	-0.72

Notes: This Table shows differences in net-present-value of earnings and retirement benefits between the baseline and the policy simulation (increase in retirement ages).

NPV: net present values; CD: Care-demand; NCD: No Care-demand

Source, SHARE, own calculations

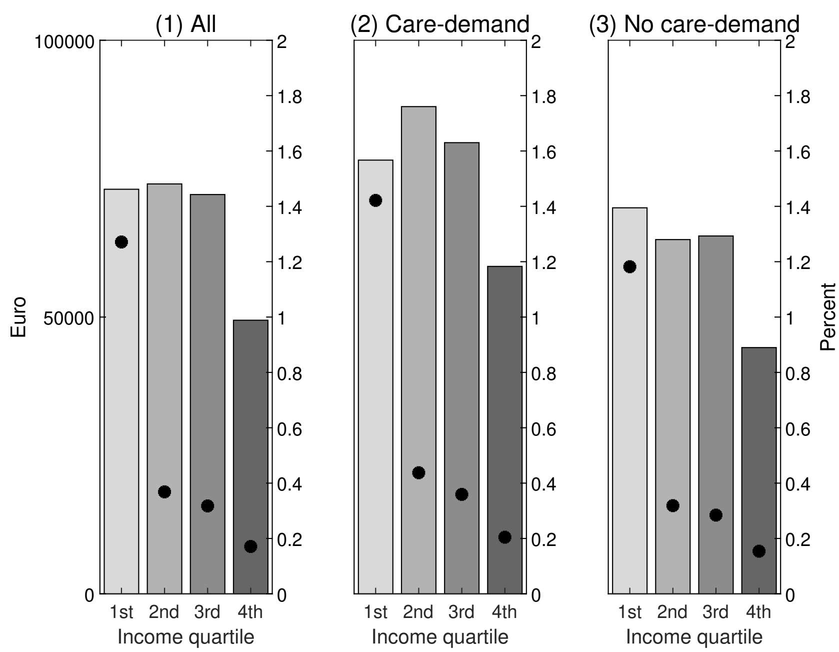
the discount factor β and survival probability ρ. NPV effects in Euro are depicted in columns 1,3 and 5, while in columns 2,4 and 6 we calculate the effects relative to baseline values. We find that for all groups effects on labor earnings are positive and retirement benefits are decreased, the total income effect of the reform is negative for all parts of the distribution. Further, women in the second income quartile increase labor income the most, the lowest quartile can compensate for lost pension benefits the least by working more. The highest income quartile experiences only a 0.72% decrease in NPV of total earnings while the lowest income quartile experiences a 3.32% decrease. In a further step, we differentiate the effects by care-demand. We define care-demand as above: Women with a least one parent who is alive at age 55 have care-demand. In columns 1 and 2 we depict effects for the full sample, in columns 3 and 4 we show effects only for those women with care-demand and in columns 5 and 6 we show effects only for those without care-demand. Be aware, that differential income effects by care-demand are a lower bound.[44] We find that women with care demand have lower increases

[44]We only look at the existence of a parent at age 55; women might never experience high care-demand probabilities

in labor earnings due to the reform, show higher reductions in retirement benefits and consequently experience higher reductions in total earnings. This results from the fact that care-demand leads to a smaller increase in employment due to the reform; the reform increases the time conflict between employment and caring.

In a last step we analyze welfare effects of the increase in retirement ages. We follow Skira (2015) and (Coe et al., 2018) and calculate the cost of well-being as a lump-sum amount of money that is necessary to equal well-being between the two scenarios. To do this we use the two simulations as above and compare the agent's life-cycle welfare between the two scenarios. We can then use our knowledge on the agent's utility function and calculate the amount of money that is necessary to make agents as well off in the policy scenario as in the baseline scenario. Well-being is affected through the scenario as agents can no longer retire before age 65 and receive less pension benefits. On the other hand, as individuals potentially work more, life-time income could be positively impacted. As seen above, the reform leads to a decrease in life-time income and well-being is most probably impacted negatively. Figure 6 depicts the sums of money necessary to compensate for lost well-being in the grey bars by

Figure 6: Welfare responses to increased retirement ages



income quartile. The dots represent the changes relative to NPV of lifetime income. We find that as women can no longer retire before age 65 they loose well-being in all income quartiles. Highest losses

and therefore never provide care. Further, it is possible, that parents die at age 56 and no care-demand remains.

in well-being are found in the second and third income quartile. The changes are largest in relative terms in the first income quartile. Women in the lowest income quartile often loose income but as they are often unemployed as a consequence, they do no loose utility from leisure. Women in the lowest income quartile need a lump-sum transfer of 73.000 Euro to be compensated for the loss in well-being, which is about 1.3% of their NPV of lifetime-income. The second and third income quartiles have lower losses in income but loose leisure time. The relative losses are smaller in comparison to their income. Women in the fourth income quartile have lower probabilities to retire before age 65 in the baseline and therefore loose less leisure and income. Figure 6 depicts effects for the whole population in the left panel. In the medium panel we present welfare effects for the group of women who can have care-demand and in the right panel we depict welfare effects for the group of women who cannot experience care-demand after age 55. We find that welfare losses are bigger for women with care-demand than for women without care-demand. Differences are biggest for women in the second and third income quartile. The reason is that women in these groups have good chances to be employed before age 65. Therefore, care-demand leads to a double burden or to a further lower increase in employment and hence income. Women in the lowest income quartile often react by unemployment and will therefore be impacted less by care-demand.

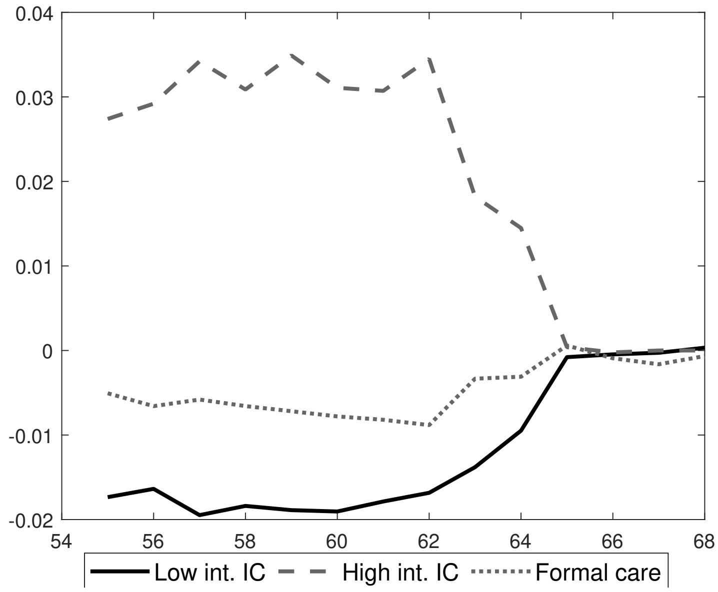
6.2 Impacts of changes to the LTC insurance

In this section we show the effects of changes to the dynamic incentive system of the LTC insurance in Germany. First, we simulate an increase in the pension points that informal care givers can collect. In this last policy simulation, we introduce the opportunity to reenter the job after having spent time in informal care provision and reducing labor hours to zero.

6.2.1 Increase in pension points collected in informal care provision

In the baseline, the model incorporates the current policy rule: Individuals who provide informal care can collect half a pension point if they do not work more than 30 hours per week. In the scenario we increase this to 1 pension point. This reduces the opportunity costs of high intensity informal care provision. One can therefore expect an increase in high intensity informal care provision. This impact is important especially before individuals go into retirement. Further, this simulation can impact labor force participation and retirement behavior through changes in the time budget (via increased informal care provision) but also as people partly provide labor hours in order to collect pension points. Figure 7 shows impacts on caring behavior. In the full sample we find an increase in high intensive informal care provision for women in the ages before retirement (55-61) of 1.57pp (50.21%) and a decrease in low intensive informal care provision by 0.91pp (11.8%). Overall, we find an increase in informal care provision before retirement ages by 0.73%. Formal care is reduced by 0.33pp (2.3%). Impacts from age

Figure 7: Care responses to increased collectable pension points



62 onward are smaller. While high intensive care is increased by 25.5%, low intensive care is decreased by 3.13% and overall, informal care is increased slightly by 0.14%. Formal care form age 62 onward is reduced by only 0.65%. If we look at impacts by education we find that lower educated women react stronger to this increased incentive. The difference in care provision effects by education emerge as the potential increase in pension benefits through informal care provision is higher for lower educated women. Due to the decreasing marginal utility from consumption, increases in pension benefits are a greater incentive for women with lower income.

Overall, employment reduced only slightly (-1.8% full-time and -0.34% part-time). Women with at least one parent alive reduce employment by 1.68%. Employment reactions are stronger for lower educated women. Overall supplied hours of work are reduced by 1.15%. Employment reactions appear as women partly work in order to increase pension benefits in later ages in the model. They can now increase pension benefits in earlier ages by providing informal care. Further, increased high intensive informal care leads to time conflicts and working becomes relatively less favorable.

In a next step, we combine the increase in collectable pension points with an increase the retirement ages (see Section 6.1).[45] Again, especially lower educated women are incentivized to increase high intensive informal care-giving. High intensive IC is increased by 44.1% before age 62 while low intensive care is decreased by 12.8%. Slightly more informal care is provided before age 62 and demand for formal

[45]Figure 27 in the Appendix shows responses this combined simulation.

care is decreased only slightly. This shows that the increase in retirement ages leads to a reduction of the incentive to provide informal care induced by collectable pension points. This emerges as individuals potentially work longer and spend less time in retirement. Individuals increase intensive informal care-giving by 41.1% from age 62 onward and reduce low intensive informal care-giving by 13.86%. Overall informal care is reduced by 0.36% from age 62 onward. Demand for formal care is increased by 2.53%. This shows a more pronounced shift from low to high intensive informal care in later ages than if retirement ages are kept constant. Further, we find only a very small reduction in informal care provision compared to the sole increase in retirement ages. This shows that as we increase the incentive to provide high intensive informal care, individuals react also when the time-conflict between work and caring is present in later ages.

Employment responses in the combined scenario are very similar to the one without the increase in collectable pension points.[46] Women increase full-time employment by 55.2% and part-time employment by 64.4% from age 62 onward. This is a slightly smaller employment effect of increased retirement ages than if collectable pension points are not increased. Before age 62, women also increase employment less than if collectable pension are not increased (6.35% vs. 11.19%). The mean retirement age increases by 1.59 years.

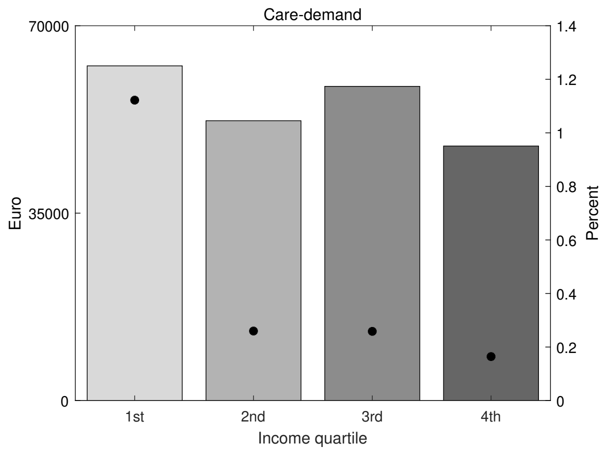
Further, we analyze impacts of the combined increase in retirement ages and increase in collectable pension points on labor earnings. We show effects only for those individuals, who have at least one parent who is alive at age 55. Women who experience no care-demand during the time span of the model are not impacted differently from scenario 1, in which only the retirement age is increased. Increases in employment are smaller when we combine the increase in retirement ages with the increase in collectable pension points in informal care provision. Therefore, Table 28 shows that consequential increases in labor earnings are smaller than in scenario 1. While in scenario 1, women increased labor earnings by 14.9% due to the increase in retirement ages, in our combined scenario, the increase is 5.34%. Again, increases are smallest in the lowest income quartile and biggest in the second income quartile. Decreases in retirement benefits are comparable to the ones shown in scenario 1 but slightly smaller. The reason is that in the combined scenario, increases in collectable pension points due to informal care times lead to increased retirement benefits. This can offset the slightly lower increase in employment and consequential lower increase in employment experience and wage increases. The NPV of total earnings, consequentially is reduced less than in the scenario in which only the retirement ages are increased.

Finally, we find that reductions in well-being are smaller for the first three income quartiles if the increase in retirement ages is accompanied by an increase in collectable pension points. Figure 8 shows monetary values necessary to offset losses in well-being induced by the combined reform. The loss in

[46]Figure 27 in the Appendix shows employment effects to the combined reform.

well-being is lower than in the baseline scenario in which only the retirement age is increased. While

Figure 8: Welfare responses to increased retirement ages combined with increased collectable pension points

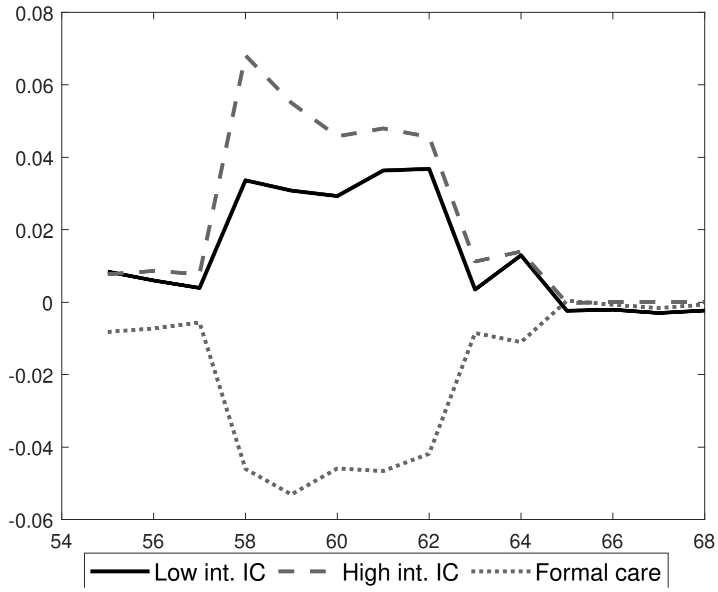


on average, women require 0.4% of their NPV of earnings to off-set the loss in well-being created by the increase in retirement ages, it is 0.29% if one includes increased collectable pension points in informal care. Highest losses in welfare can now be found in income quartile 1, showing that the second and third income quartile profit relatively more from the increase in collectable pension points in terms of well-being.

6.2.2 Introduction of 'care-times'

Germany has already introduced policies that make it possible to reduce labor hours while providing care for a close relative and returning to the job after a short leave. This policy is not introduced into the model in the baseline. This simulation therefore gives a measure of the importance of labor market frictions in the uptake of informal care provision. Figure 9 shows responses in care provision by age. We see that as labor market frictions are removed for informal care provision, high and low intensive informal care provision are increased while demand for formal care is reduced. These responses are important especially until age 63 when most women hit retirement ages. We find that high intensive informal care provision is increased by 1.48pp (52.5%) and low intensive informal care provision is increased by 0.93pp (12.2%) before age 64. Formal care provision is reduced by 1.3pp (8.9%). Formal care demand is decreased by 1.67pp (8.68%) for highly educated women and by 1.07pp (9.09%) for lower educated women. We find increases in high intensive IC in retirement ages (ages 64 and older) by 0.07pp (7.48%) and low intensive IC (0,04pp; 0.62%). Formal care is not impacted much in ages from 64 onward. Overall, we find that through the introduction of care-times, 17.43% more informal

Figure 9: Care responses to the introduction of care-times



care and 26.2% more informal care hours are provided.

We find increases in part and full-time employment and increases in unemployment.[47] Before age 64 we find a 3.13pp (9.4%) decrease in part-time employment and a 1.08pp (4.15%) decrease in full-time employment and a 4.21pp (10.29%) increase in non-work. The increase in unemployment before age 64 is 4.7pp (13.7%) and retirement behavior is hardly impacted (0.07pp or 0.75% decrease in the probability to be retired by age 63). We still find reductions in part-time (-0.17pp, -3.64%) and full-time (-0.05pp, -2.69%) employment from age 64 onward. Retirement probabilities are decreased slightly (-0.26%) while unemployment is increased by 2.53%. The mean retirement age is increased slightly (by 0.016 years) and overall, working hours are decreased by 6.24 hours.

In the next step we combine the increase of retirement ages to 67 (ERA to 65) with the introduction of care-times. We do this in order to understand whether the introduction of care times can absorb the detrimental care effects of increased retirement ages. Individuals react to the introduction of care times and decrease full- and part-time employment and increase unemployment.[48] Decreases in employment are however smaller than when we only introduce care-times. At age 58, women reduce employment by 6.41pp (compared to a 7.31pp reduction if care-times are introduced without altering the retirement ages). The reason is that the increased retirement age induces a further incentive to

[47]Figure 28 in the Appendix show employment responses to the introduction of care times for women who have at least one parent alive at age 55.

[48]Figure 30 shows employment effects of the combined reform.

work. While changes to retirement are similar to the increase in retirement ages without introducing care-times, employment is increased less in this combined scenario. At age 63, we find a 29.5pp increase in employment in scenario 1, while in this combined scenario, we find a 23.5pp increase in employment. Especially part-time employment is increased less than in scenario 1. The result is an stronger increase in unemployment if we combine the increased retirement age with the introduction of care-times. Further, we find a 5.96% decrease in the demand for formal care in the combined scenario while in scenario 1, demand for formal care is increased by 2.9% overall.

We can further analyze the impact of the combined reform on the NPV of labor earnings, retirement benefits and total earnings. We find that for the group of women who have at least one parent that is alive at age 55, labor earnings increase by less than half if we introduce care-times in combination with increased retirement ages in comparison to the sole increase in retirement ages. While the NPV of labor earnings increase by 14.9% if retirement ages are increase, the combined reform leads to an increase by 4.9%. The reason is that due to the introduction of care-times, women with care-demand more often go into unemployment before retirement ages. In upper income quartiles we even find a decrease in labor earnings. Reductions in retirement benefits are slightly lower. Total earnings are reduced less as a consequence.

Figure 10: Welfare responses to increased retirement ages combined with the introduction of care-times

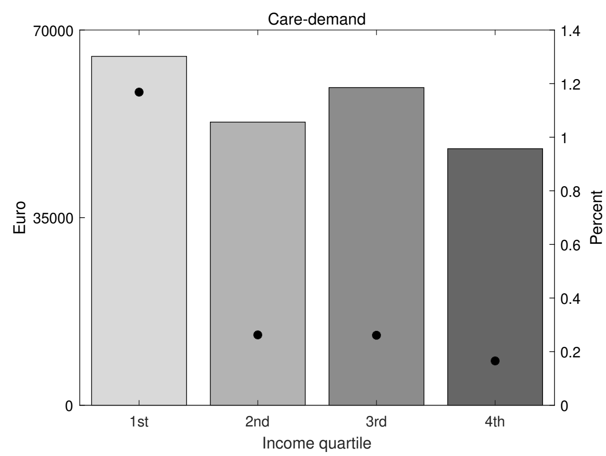


Figure 10 shows well-being effects in monetary terms and in percent of earnings if we combine increased retirement ages with the introduction of care-times. The figure shows effects for women with potential care-demand. We see that the negative consequences of increased retirement ages on well-being are reduced due to the introduction of care-times. Negative consequences are reduced from 0.4% of total earnings to 0.29%. This effect is very close to the reduction in negative well-being effects by the increase in collectable pension points in informal care provision. However, effects are differently distributed. As we can see in Figure 10, negative effects are highest for the lowest income quartile. While negative effects are reduced more for income quartiles 2-4 by the introduction of care-times than by the increase in collectable pension points, income quartile 1 is alleviated less in this scenario.

6.3 Fiscal effects

In this section we describe fiscal effects of the important counterfactual policy reforms. In order to asses the efficiency of policy reforms one needs to understand its fiscal implications. We calculate fiscal implications in all aspects of the tax and transfer system that we model: Pension system, Social security benefits, LTC insurance benefits, social security contributions and taxes. Table 10 shows results. Positive values represent a surplus for the respective entity (state or insurance), while negative values represent losses. We calculate differences between the scenario of interest and the baseline simulation and report mean differences over all observations and relative results. In columns 1 and 2 we show results of increased retirement (see Section 6.1) ages after which we show implications of combined reforms: In columns 3-4 we show fiscal effects of combining increased retirement ages with increases in collectable pension points (see Section 6.2.1) and in columns 5 and 6 we show effects if increased retirement ages are combined with the introduction of care-times (see Section 6.2.2).

We find that the pension system receives a surplus in all three scenarios. As retirement ages are delayed and we do not change contributions to the system, this was to be expected. We find that the combined scenarios show lower surpluses for the pension system due to the fact that more individuals provide informal care and can increase pension benefits. Also, labor hours are increased less and this leads to a reduction in pension benefits. Social security benefits are increased as more individuals are unemployed in all 3 scenarios. Highest increases are found in columns 5 and 6 as women go into unemployment also before possible retirement ages in order to provide informal care. LTC cash benefits are paid out in case informal care is provided. We see that in the main scenario less informal care is given and hence, cash benefits payout is decreased. In further (combined) scenarios we find an overall increase in informal care provision which leads to an increase in cash benefit payout. Informal care provision increases more in the scenario with introduced care-times. We LTC in-kind benefits paid out in case of formal care usage in row 4. We define benefit amounts according to respective care dependency levels and use full amounts of in-kind benefits as defined by the German LTC insurance. We see the opposite effect to cash-benefits: While in the main scenario, more formal care is demanded, in-kin benefits increase, we see a decrease in in-kind benefits in the combined scenarios. We find that as costs of formal care are higher, the net effect for the LTC insurance is negative in the main scenario but positive in the combined scenarios. We find an increase in the amounts of social security contributions and taxes paid in all three scenarios due to an increase in labor supply. The total net effect of the main scenario is highest while combined scenarios show smaller but positive net effects. We find that

LTC insurance effects are of smaller size than effects in pension system, taxes or social security system. The net effect of the combines reform incorporating an increase in collectable pension points is higher than if care-times are introduced.

Table 10: Fiscal effects of increasing retirement ages

	Increased retirment ages					
			Pension points		Care times	
	Euro in 1000	%	Euro in 1000	%	Euro in 1000	%
Pension payout	47.2	17.31	26.8	9.83	29.1	10.68
Social security benefits	-5.98	-21.07	-7.15	-25.18	-10.9	-38.51
LTCI cash benefits	0.07	4.13	-0.1	-6.14	-0.37	-22.75
LTCI in-kind benefits	-0.15	-0.73	0.22	1.05	0.90	4.85
Social security contributions	8.85	7.11	7.80	6.27	3.52	2.82
Income tax	0.11	0.01	5.85	0.45	2.51	0.19
Net effect	50.1	0.03	33.4	0.02	24.8	0.01

This Table shows fiscal effects of increased retirement ages (columns 1-2), combined with increased collectable pension points (columns 3-4) or the introduction of care-times (columns 5-6). Positive values represent a surplus, negative values losses for the insurance or state.

7 Conclusion

In this paper we analyze the effects of increased labor market participation of women on informal and formal care-giving to frail parent and the role of the pension system and long-term care insurance in Germany therein. Concentrating on women in the ages 55-68, we build a dynamic structural model to incorporate the dynamic nature of labor market and retirement decisions as well as the long-term incentive structure. We estimate the model using data from the German part of the Survey of Health, Ageing and Retirement in Europe (SHARE) as well as the German Socio-Economic Panel (GSOEP) applying maximum likelihood. Using the estimated structural parameters we simulate policy changes and compare outcomes with a baseline simulation. In these policy simulations, we analyze how an increase in the retirement ages, induced by an increase of the normal and early retirement ages and reduced generosity of the pension system can impact the decision for provide informal care as well as formal care organization. We then explore the role of labor market frictions and pension points collected in informal care demand in the decision to provide informal care and the care-mix.

When increasing the labor force participation of women at age 54, women work more in the short and long-term. This leads to increased time-conflicts between paid employment and informal care provision. As a result, especially high intensive informal care provision is reduced and we see a shift toward low intensive care provision. Demand for formal care is not increased as a consequence. Further, our model points to the fact that employment responses toward increased retirement ages can vary by care-demand. As women have elderly parents they increase employment less and have a higher probability to be unemployed compared to women who have no parent that is still alive. In a first policy simulation, we increase retirement ages to 67 (NRA) and 65 (ERA) and find that as the time-conflict intensifies less informal care is provided. As a consequence, the demand for formal care increases. We can show that women with potential for care-demand loose more income and are impacted more in their well-being through the introduction of this reform. As we simulate the introduction of care times- the possibility to return to the job after having provided informal care - we see an increase in informal care provision. This reduces the demand for formal care. As we give the opportunity to reduce labor hours to zero while providing informal care, our model predicts a decrease in employment and and increase in unemployment while women provide informal care to a frail parent. This simulation shows that labor market frictions play a role in the decision to provide informal care. Korfhage (2019) and Skira (2015) can show that labor market frictions play an important role in the negative impact of informal care provision on long-term labor market outcomes such as wages and pension benefits. We point to the other side of the equation: Women take labor market frictions into account when deciding whether to provide informal care and reduce labor hours. Further, we point to the fact that pension points that are collected in informal care provision are an important incentive especially for high intensive informal care provision.

The results of our paper suggest that changes in female labor force participation and increased retirement ages lead to reduced informal care provision and increased demand for formal care. Our notion is that informal and formal care are no perfect substitutes but rather complement each other dependent on the kind of care dependency. Still, as no informal care is provided due to increased opportunity costs, formal care is in higher demand. Further, our paper suggests that further policy measures like increased pension points collected in informal care times or the introduction of care times, similar to child-care times can alleviate the reduction in informal care supply but come with long-term fiscal and individual labor market costs. For a group of women, the increased labor market participation is coupled with provision of informal care which is burdensome for mental and physical health. This comes with long-term health costs for individuals as well as fiscal costs for public health insurance.

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A Appendix

A.1 Definition of variables in SHARE

Retirement Individuals are considered retired if they respond to be retired in the question on their current job situation. In addition, individuals are considered retired if they respond not to be working and respond to be receiving old age pension benefits.

Working Individuals are considered part-time employed if they respond to be working and provide a number of working hours within the 5th to 50th percentile of the distribution of working hours. This corresponds to 10 to 32 hours per week. Individuals are considered full-time employed if they work more than the median of hours in the distribution of working hours (more than 32 hours per week). In the model we consider the mass-points of the distribution at the 25th percentile (20hours per week) and 75th percentile of the distribution (40 hours per week) for working women as part- and full- time work.

Care provision Individuals in SHARE give information on providing help to family members and close friends outside their own household; they inform about three different individuals they provide care for, state their relationship to them and inform on how regularly they provide care for them. We consider only care to parents (own mother or own father). Care provided almost every day is considered intensive care while care provided less often (every week, every month and less often) is considered non-intensive care. Further, individuals report on personal care they provide for individuals in their own household. If a respondent states to provide personal care to a parent who lives in the same household we consider this as intensive informal care. In order to include information on formal care we use predictions resting on an estimation on elderly respondents in SHARE ($age >= 69$) who have at least one child (see section on estimation).

Years in retirement Individuals give information on the time they have spend in retirement. If the information is missing and individuals are considered retired we use information given in SHARElife to construct retrospectively the year in which the last job ended.

Number of care years Individuals inform on care provided to any person in each wave. We make use of individuals who report to have given care in any former period and produce a variable giving the number of care years. This information cannot be enriched by SHARElife data as care provision is not covered retrospectively.

Parental information Individuals give information on parental age, health and distance individually by parent. We use this information plainly as given. If individuals respond in several waves we impute missing parental information given information in periods around the missing data point. We use the information on parental health and re-code it to reduce the size of the state space: We combine the statements on "very good" and "excellent" health to "good" health; we combine "good" and "fair" to "medium" and "poor" is renamed "bad". On the side of parents we use the information on self-assessed health and proceed the same way. Further, we use information on number of children and construct an indicator whether one child lives close by or not. Individuals further give information on number of siblings which we exploit in the prediction of the probability of formal care provision for parents given the number of children on the side of the parents.

Partner We use marriage information in SHARE to construct an indicator on the existence of a partner living in the same household. We do not distinguish between marriage and registered partnership.

Education We use information in years of education and professional qualification to construct an indicator for high education. If an individual reports at least 15 years of schooling, a practical training with the degree of a master craftsman or any kind of university degree we consider this person as highly educated.

A.2 Description of Parent child data set

We use all observations in SHARE on individuals aged 65 and older and expand it along their children to construct the parent-child data set. Given the rich information elderly respondents give on their children, we construct a data set we use to estimate the care demand and impute formal care usage. Table 11 shows summary statistics on parental and child information in the data set.

A.3 SOEP Data

We make use of the German Socio-economic Panel (GSOEP)[49] in order to estimate the parameters of the wage function and health transitions. The following variables are created:

A.3.1 SOEP Data- Variable definitions

Wage The SOEP data set contains a constructed variable on the yearly wage of the individual from their main job and their secondary job before taxes. In order to create the hourly wage we additionally use a variable containing the annual work hours of the individual.

Experience SOEP data contains constructed information on the years of part-time and full-time employment, which is used to construct an individual experience level.

Education In line with the definition in SHARE individuals are considered to have high education if they either report at least 15 years of schooling, a practical training with the degree of a master craftsman or any kind of university degree.

[49] Goebel et al. (2019)

Table 11: Summary table on the parent-child data set- SHARE

	Male	Female	Total
Parent information			
Age	73.17	73.93	73.56
	(6.041)	(6.682)	(6.391)
Year	2011.3	2011.3	2011.3
	(3.958)	(4.009)	(3.984)
Highly educated	0.114	0.0922	0.103
	(0.318)	(0.289)	(0.304)
Number of children	2.864	2.860	2.862
	(1.397)	(1.324)	(1.360)
Marital status	0.845	0.605	0.721
	(0.362)	(0.489)	(0.449)
Self reported health	3.369	3.511	3.443
	(0.985)	(0.917)	(0.953)
Formal care usage	0.0855	0.139	0.113
	(0.280)	(0.346)	(0.317)
Number of parent observations	1,744	1,838	3,582
Children information			
Age	44.26	47.64	46.01
	(28.51)	(7.779)	(20.65)
Frequency of visit (categorical)	2.920	2.746	2.830
	(1.610)	(1.546)	(1.580)
Birth year	1967.0	1963.7	1965.3
	(28.60)	(8.293)	(20.81)
Female	0.493	0.486	0.490
	(0.500)	(0.500)	(0.500)
Distance to parents (categorical)	5.148	5.000	5.072
	(1.845)	(1.875)	(1.862)
Marital status	1.407	1.369	1.387
	(0.491)	(0.483)	(0.487)
Labor market status (categorical)	2.227	2.218	2.223
	(0.735)	(0.792)	(0.765)
Provide informal care to parent	0.0461	0.105	0.0768
	(0.210)	(0.307)	(0.266)
Number if child observations	9,840	10,123	19,963

Region We use SOEP data to construct a variable informing on whether a household lives in parts of Germany formerly belonging to the DDR.

Health SOEP contains information on self reported health status. It is given every period, which we use to construct a lagged health status. In line with SHARE we construct a 3 fold health indicator from the original variable with 5 levels: We combine the statements on "very good" and "good" health to "good" health; "satisfactory" becomes "medium" and "poor" and "bad" is renamed "bad".

Non-labor income Non-labor income is defined as household pre-government income minus own and partner labor income.

Partner income In order to estimate partner income we make use of SOEP's household dimension and use labor income of a spouse living in the same household. We also include other sort of partner specific income (pension etc.).

A.3.2 SOEP data- sample description

In our SOEP data set we end up with 46,249 observations on 5,418 women. Table 12 shows important summary statistics for this data set (women in SOEP observed between 2001 and 2018, aged 55-68. This data set is used to estimate the wage equation as well as non-labor income and partner income. The last 12 rows show mean self-reported health status of men and women aged 69 and older. This data on 64,021 observation on 5,876 individuals is used to estimate health transitions. In German SOEP data we can observe the care level of individuals who live in private households and report their care dependency.[50] We find that of the 4,611 individuals reporting to be care dependent, 56.3% report to be in care level 2, 30.5% in care level 3, 10.9% in care level 3. Only 1.8% are in care level 1 and only 0.34% report to be in care level 5. Discrepancies to the official data are partly due to the fact that SOEP contains very few individuals living in care facilities. Partly, reporting issues arise. Also, as the care levels were reformed in 2017 but data comes from the years 2001-2018, harmonising the reported levels is difficult. Of all individuals reporting a care level, 46% report to be in bad health, and 30% report poor health. With increasing care levels the proportions shift toward worse self-reported health.

A.4 Formal care imputation: estimation

As we do not observe, whether individuals organize formal care for their care dependent parents we must impute the formal care choice. We do this making use of the information in the parent-child data set, separately for men and women. Using individuals aged 70 and older who have as least one child, we regress the binary indicator ($FC_{t,parent}$), indicating whether a person receives formal care on own information (age, number of children, health status) and information on each of the children (age, marriage status, how often they meet their parent, birth date, gender, distance to the parent,

[50]SHARE data does not contain information on the care level.

Table 12: Summary table SOEP data

Age	58.99
	(3.124)
Year of observation	2011.6
	(5.688)
Highly educated	0.240
	(0.428)
Married	0.925
	(0.264)
Retired	0.40
	(0.49)
Employed	0.35
	(0.47)
Mean wage (all)	14.24
	(9.445)
Mean wage (employed)	17.55
	(21.62)
Experience	27.08
	(9.641)
Partner income	34314.0
	(33552.5)
Non labor income	4436.9
	(20703.0)
Current Self-Rated Health Status Women	
Good	0.20
	(.40)
Medium	0.41
	(0.49)
Bad	0.37
	(0.48)
Current Self-Rated Health Status Men	
Good	0.26
	(0.43)
Medium	0.43
	(0.49)
Bad	0.28
	(0.45)

labor market status, education and whether they provide informal care fore their parent) in a logit estimation. Many of those variables are introduced as fixed effects in the estimation, e.g. number of children fixed effects (α_{Nchild}).This is done in order not to make linearity assumptions and have better predictions. Parameters from this estimation on men and women (mothers and fathers) separately are then used to predict the probability of formal care usage for each individual parent in the estimation data set. We use the resulting parent specific probability to construct a probability that a parent receives formal care as:

$$\begin{aligned} P(FC_t = 1) = P(FC_{t,mother} = 1) + P(FC_{t,father} = 1) \\ -(P(FC_{t,mother} = 1) * P(FC_{t,father} = 1)) \end{aligned} \tag{14}$$

For the final estimation data set we create a binary indicator if an individual organizes formal care for a parent from the smooth probability. We draw a random number from a uniform distribution (between 0 and 1) and compare it to the predicted probability. In this way we can carry the population mean on formal care organization into the model. We estimate the probability that any given parent receives formal care given parental information (age, age squared, number of children, health, marital status) and child information provided by the parents (age, age squared, whether the child gives informal care ot the parent ($Icare$), marital status, employment status, gender, educational attainment, birth year (*cohort*), distance to parents and frequency of visits to parent). We introduce all variables, except age as fixed effects into the estimation.

$$\begin{aligned} FC_{t,parent} = & FC_{t,parent}(\delta, age_{parent}, age^2_{parent}, age_{child}, age^2_{child}, Icare_{child}, \\ & Nchild_{parent}, Health_{parent}, married_{parent}, married_{child}, empl_{child}, \\ & gender_{child} educ_{child}, cohort_{child}, dist_{child}, frequency_{child}) \end{aligned} \tag{15}$$

, with $parent \in \{mother, father\}$.

Given the parent-child data set from SHARE (see section A.2) we estimate the probability of any parent using formal care in a probit estimation. The residual categories are always baseline (Number of children:1; Healh of parent: excellent; Non-married parent or/and child; distance to child: in the same building; employment status of child: retired). See Tables 14 and 13 for results.

A.5 Limitations with activities of daily living

In SHARE data, individuals give information on limitations with activities of daily living (ADL) as well as Limitations with instrumental activities of daily living (IADL) they face. We construct a categorcial variable stating whether one faces at least two ADL and at least 1 IADL (category 1), at least 3 ADL and at least 3 IADL (category 2) or at least 5 ADL and at least 5 IADL. The residual category 0 defines less than 2 ADL and no IADL. These categories are close to the definitions of care levels in the

Table 13: Regression for imputation of formal care usage for females

VARIABLES	(1) Formal care usage
Age	-0.681***
	(0.153)
Age squared	0.00514***
	(0.000989)
Number of children:2	0.147
	(0.161)
3	0.300*
	(0.163)
4	0.280
	(0.180)
5	-0.133
	(0.213)
6	0.0634
	(0.306)
7	0.492
	(0.574)
8	1.821***
	(0.649)
Very good health Health	-2.657***
	(0.562)
Good Health	-0.592*
	(0.329)
Fair Health	0.114
	(0.324)
Poor Health	1.230***
	(0.330)
Age child	0.0941
	(0.105)
Age child squared	-5.34e-05
	(0.00102)
Parent married	-0.391***
	(0.102)
Birth year child	.0513
	(.00679)
Child is female	0.0119
	(0.0930)
Distance to child	
Less than 1 kilometre away	0.180
	(0.316)
Between 1 and 5 kilometres away	0.547*
	(0.304)
Between 5 and 25 kilometres away	0.108
	(0.306)
Between 25 and 100 kilometres away	0.286
	(0.297)
Between 100 and 500 kilometres away	0.372
	(0.305)
More than 500 kilometres away	0.258
	(0.305)
More than 500 kilometres away in another country	-0.0548
	(0.332)
Child married	-0.142
	(0.0980)
Employment status child	
Working	-0.357*
	(0.211)
Unemployed	-0.121
	(0.270)
Disabled or sick	-0.0925
	(0.373)
Homemaker	-0.570**
	(0.277)
Highly educated child	0.0199
	(0.179)
Provide informal care to parent	.3020***
	.0716429
Constant	21.17***
	(5.801)
Observations	5,553

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 14: Regression for imputation of formal care usage for males

VARIABLES	(1) Formal care usage
Age	0.153
	(0.222)
Age squared	-0.000315
	(0.00142)
Number of children:2	0.369
	(0.228)
3	0.267
	(0.234)
4	0.414*
	(0.249)
5	0.544*
	(0.285)
6	1.785***
	(0.341)
7	0.485
	(0.438)
8	0.524
	(0.580)
9	2.518***
	(0.430)
Very good health Health	-0.187
	(0.507)
Good Health	0.0596
	(0.445)
Fair Health	0.851*
	(0.438)
Poor Health	2.470***
	(0.440)
Age child	0.498***
	(0.161)
Age child squared	-0.00360**
	(0.00161)
Parent married	-0.928***
	(0.139)
Birth year child	0.071
	(.00976)
Child is female	0.175
	(0.120)
Distance to child	
Less than 1 kilometre away	-0.186
	(0.479)
Between 1 and 5 kilometres away	0.236
	(0.449)
Between 5 and 25 kilometres away	-0.0803
	(0.446)
Between 25 and 100 kilometres away	0.0163
	(0.439)
Between 100 and 500 kilometres away	0.372
	(0.442)
More than 500 kilometres away	0.352
	(0.440)
More than 500 kilometres away in another country	-0.0713
	(0.473)
Child married	-0.107
	(0.128)
Employment status child	
Working	-0.751**
	(0.335)
Unemployed	-0.269
	(0.397)
Disabled or sick	0.0757
	(0.539)
Homemaker	-1.201***
	(0.441)
Highly educated child	-0.274
	(0.192)
Provide informal care to parent	1.225***
	(0.203)
Constant	-20.37**
	(8.323)
Observations	5,146

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

German LTCS. Category 1 defines care level 2, category 2 defines care level 3 and category 3 defines care level 4. The residual care levels 1 and 5 are very specific and are difficult to define with the data at hand. We use the parent-child data set to estimate the parameters of multinomial regression given the following specification separately for males and females:

$$B^j_{t,parent} = \omega_1 age + \omega_2 age^2 + \omega_3 health_{good} + \omega_4 health_{medium} + \omega_5 health_{bad} + \omega_6 \tag{16}$$

The estimation results are given in Table 15.

We formulate the probability of any of the categories ($ADL_t \in \{1-3\}$) depending on the state vector and Q_t as a multinomial-logit probability. We then calculate the probability that the agent observes any of the discrete ADL categories for the parents facing demand following equation 17, which includes separate probabilities of either parent facing any of the ALD categories. These are formulated according to equation 18 for care following the closed form multinomial logit probability.

$$\begin{aligned} P(ADL_t = j) = P(ADL_{t,mother} = j) + P(ADL_{t,father} = j) \\ -(P(ADL_{t,mother} = j) * P(ADL_{t,father} = j)) \end{aligned} \tag{17}$$

$$P(ADL_{t,parent} = j) = \frac{exp(B^j_{t,parent})}{1 + exp(B^j_{t,parent})} \tag{18}$$

,with $B^j_{t,parent}(\psi, age_{parent}, health_{parent})$ for $parent \in \{father, mother\}$ and $j \in \{1-5\}$.

The predicted ADL, that any given indidivual faces combined for her parents is then used to calculate LTC benefits and costs of formal care usage. Further the separate ADL categories for both parents are used to calculate formal care-demand.

A.6 Care Demand

In order to estimate the care demand paremeters for formal and informal care demand we use SHARE data on individuals aged 69 and older.

A.6.1 Formal care demand

Using the information health, age and marital status we estimate the probability that any given parent uses formal care. The outcome variable is the usage of formal care in the parent household. We estimate the probability that any given household of parents uses formal care give the information separately on single parent households (male and female separately) and households with both parents. Parameters are given in Table 16. In the next step we use predicted probabilities of care demand to find out the impact of existence of siblings and the distance to parents on care provision by children. We do

Table 15: Probability to have limitations with activities of daily living- multinomial regression

	(1) Female	(2) Male
Limitation Category 1		
Age	-0.185	-0.242
	(0.199)	(0.252)
Age squared	0.002	0.002
	(0.001)	(0.002)
Good health	-2.190***	-1.883***
	(0.723)	(0.705)
Medium health	-0.814	-0.639
	(0.721)	(0.701)
Bad health	0.118	0.464
	(0.727)	(0.708)
Constant	4.264	4.934
	(7.838)	(9.860)
Limitation Category 2		
Age	-0.524*	-0.687*
	(0.270)	(0.357)
Age squared	0.004**	0.005**
	(0.002)	(0.002)
Good health	12.202	-3.359***
	(1508.795)	(0.857)
Medium health	14.205	-1.454*
	(1508.795)	(0.826)
Bad health	16.052	0.894
	(1508.795)	(0.824)
Constant	-1.236	21.584
	(1508.834)	(14.023)
Limitation Category 3		
Age	-0.658**	-0.679**
	(0.274)	(0.341)
Age squared	0.005***	0.005**
	(0.002)	(0.002)
Good health	-3.755***	-2.922***
	(0.774)	(0.871)
Medium health	-2.136***	-1.334
	(0.756)	(0.853)
Bad health	0.241	1.072
	(0.758)	(0.851)
Constant	17.559	19.526
	(11.121)	(13.496)
N	3820	3840

Standard errors in parentheses
* p¡0.10, ** p¡0.05, *** p¡.01

this by estimating the impact of these factors (predicted formal care demand, information on siblings and distance to parents) on the probability that any given child organizes formal care for a parent. These predicted probabilities from the care demand estimation are then carried over to the model and adjusted by these factors according to information on distance to parents and existence of siblings.

A.6.2 Informal care demand

For the estimation of informal care demand we use information on parental health, age and marital status to estimate the probability that a parent household uses informal care (any informal care form outside the household, no informal care from the spouse). The parameters are given in Table 17. As for formal care we then use predicted informal care demand and measure the impact of distance to parents and existence of sibling. To do that we regress the information that any given child provided informal care to a parent on predicted informal care demand and the information on distance to parents and existence of siblings. We use the parameters to predict care demand in the model and adjust them accordingly using the estimated impact of parental distance and existence of siblings.

A.7 Health transitions

Health transitions of the parents follow a process estimated outside the model on SOEP data.[51] We estimate a simple multinomial logit model on three possible health outcomes of fathers and mothers separately.

The functional form looks as follows:

$$\begin{aligned} health_{t+1} = &\alpha_0 + \alpha_1 age + \alpha_2 age^2 + \alpha_3 \mathbb{1}(health_t = good) + \\ &\alpha_4 \mathbb{1}(health_t = medium) + \alpha_5 \mathbb{1}(health_t = bad) \end{aligned} \tag{19}$$

We estimate this on separate data sets of men and women respectively, aged 69 and older. We use the self assessed health status reported in SOEP. Tables 18 and 19 show the parameters of the health transition estimation. The parameters are difficult to interpret. Sign and size have some explanatory power: The probability to be of medium and bad health in some period depends positively on age while higher age increases the probability to be of bad health more. A good health status in the last period reduces the probability of a medium or bad health status now while medium and bad health status in the last period increases this probability now. The estimation takes a good health status as base category and after predicting probabilities for medium and bad health based on the parameters shown in the Table the probability of good health is the residual of the other two.

[51]For details on SOEP see A.3

Table 16: Care-demand for formal care- couples and single parents

	(1)	(2)	(3)
	Received informal care		
	Single mothers	Single fathers	Couple
Age of parent	-0.921***	-0.321	
	(-5.73)	(-1.29)	
Age of parent squared	0.00616***	0.00246	
	(6.15)	(1.57)	
Health of parent			
Medium	0.836***	0.499***	
	(9.57)	(4.29)	
Bad	1.715***	0.982***	
	(15.99)	(5.90)	
Parent(s) live close	0.0192	-0.000733	-0.0562
	(0.25)	(-0.01)	(-1.26)
Age of mother			0.0340***
			(6.05)
Age of father			0.0252***
			(3.93)
Health of mother			
Medium			0.277***
			(5.73)
Bad			0.651***
			(9.84)
Health of father			
Medium			0.322***
			(6.50)
Bad			1.169***
			(19.02)
Constant	32.79***	9.012	-5.799***
	(5.10)	(0.91)	(-16.49)
N	1634	760	4860

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 17: Care-demand informal care- couples and single parents

	(1)	(2)	(3)
	Received informal care		
	Single mothers	Single fathers	Couple
Age of parent	0.0358	-0.00244	
	(0.36)	(-0.01)	
Age of parent squared	-0.0000129	0.000386	
	(-0.02)	(0.32)	
Health of parent			
Medium	0.422***	0.272**	
	(7.52)	(2.89)	
Bad	0.724***	0.900***	
	(9.98)	(6.56)	
Age of mother			-0.00432
			(-1.06)
Age of father			0.0427***
			(8.98)
Health of mother			
Medium			0.353***
			(9.81)
Bad			0.515***
			(9.97)
Health of father			
Medium			0.347***
			(9.55)
Bad			0.974***
			(19.95)
Constant	-3.100	-2.744	-3.867***
	(-0.77)	(-0.36)	(-14.90)
N	2586	961	6876

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 18: Health transitions Women

	(1)	(2)	(3)
Health outcome	Good health	Medium health	Bad health
Age		0.0304***	0.196***
		(0.00321)	(0.0447)
Age squared		-1.31e-05*	-0.000885***
		(7.93e-06)	(0.000282)
Lagged health good		-1.155***	-2.558***
		(0.0486)	(0.0617)
Lagged health medium		0.736***	-0.109**
		(0.0478)	(0.0504)
Lagged health bad		1.434***	2.663***
		(0.0691)	(0.0682)
Constant		-1.550***	-9.220***
		(0.225)	(1.763)
Observations		40,937	
Pseudo R-squared		0.2002	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 19: Health transitions Men

	(1)	(2)	(3)
Health outcome	Good health	Medium health	Bad health
Age		0.176***	0.260***
		(0.0645)	(0.0757)
Age squared		-0.000968**	-0.00134***
		(0.000414)	(0.000484)
Lagged health good		-1.047***	-2.472***
		(0.0503)	(0.0680)
Lagged health medium		1.016***	0.115**
		(0.0502)	(0.0557)
Lagged health bad		1.743***	3.067***
		(0.0788)	(0.0789)
Constant		-7.374***	-11.89***
		(2.502)	(2.946)
Observations		33,965	
Pseudo R-squared		0.2170	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

A.8 Wage function estimation

The wage function looks as follows:

$$\begin{aligned} ln(wage_t) =& \omega_0 + \omega_1 \mathbb{1}(age_t >= 60) + (\omega_2 + \omega_3 \mathbb{1}(educ = 1))exp_t + \\ & omega_4 + \omega_5 \mathbb{1}(educ = 1))exp_t^2 + \omega_9 \mathbb{1}(educ = 1) + \omega_{year} YEAR \end{aligned} \tag{20}$$

As can be seen in equation 20, wages can increase with experience which is an incentive to work. Also, returns to experience are allowed to vary with education. To incorporate changing macroeconomic conditions, we include a year fixed effect. We use SOEP data to estimate the wage process. Low wages of an individual are estimated dependant on gender, experience, education and the region of habitation. The estimation procedure is conducted on a sample of all employed individuals aged 55 to 69, the ages of interest in the model using a simple linear OLS regression. High education is defined according to the definition used in the SHARE data set: having at least 15 years of education, a finished master training or some university degree. Part time employment is counted as half years of experience. Table 20 shows the parameters from the wage estimation. Females have lower hourly wages. Experience seems to impact the hourly wage deferentially by education, age and sex.

A.9 Non-labor income parameters

On a similar data set we estimate the parameters for non-labor income. Non-labor income is influenced by education, age and the existence of a partner. We use age in linear and quadratic form and on top include a indicator on being older than 64 in order to account for changes on non-labor income in old age and retirement. Equation 21 shows the specification.

$$ln(A_t) = \eta_0 + \eta_1 \mathbb{1}(age_t >= 65) + \eta_2 \mathbb{1}(educ = 1) + \eta_3 age_t + \eta_4 age_t^2 \tag{21}$$

Parameter estimates are shown in table 21. For the estimation, non-labor income is used in logarithmic form.

A.10 Partner income parameters

We use following regression to estimate spousal income parameters κ :

$$ln(SI_t) = \kappa_0 + \kappa_1 \mathbb{1}(age_t >= 65) + \kappa_2 \mathbb{1}(educ = 1)(\kappa_3 +) age_t + \kappa_4 age_t^2 + \kappa_{year} YEAR \tag{22}$$

To include partner income into the model, we estimate the influence of education and age on all women with a partner on logarithmic partner income. Table 22 shows parameters which are then used in the model.

Table 20: Wage function

	(1)
Outcome	Wage (logarithmic)
Sex	-0.414***
	(0.0433)
Experience	0.000627
	(0.00259)
Experience squared	0.00770*
	(0.00458)
Experience *High Education	0.0204***
	(0.00307)
Experience squared *High Education	-0.0513***
	(0.00559)
High Education	0.307***
	(0.0415)
Experience *Older than 60 years	-0.000234
	(0.000221)
Experience Females	0.0108***
	(0.00309)
Experience squared Females	-0.0156***
	(0.00564)
Year of observation	0.0128***
	(0.000584)
Constant	-23.12***
	(1.172)
Observations	38,812
R-squared	0.155

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 21: Partner income

	(1)
Outcome	Partner Income
Education	0.358***
	(0.00787)
Age	0.117***
	(0.0427)
Age squared	-0.00129***
	(0.000356)
Age >= 65	-0.00548
	(0.0183)
Year of observation	0.0210***
	(0.000660)
Constant	-35.27***
	(1.865)
Observations	57,130
R-squared	0.133

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 22: Non-labor income

	(1)
Outcome	Non labor income
High Education	0.752***
	(0.0138)
Age	-0.147**
	(0.0738)
Age squared	0.00184***
	(0.000617)
Age >= 65	0.00264
	(0.0320)
Married	0.479***
	(0.0151)
Constant	7.883***
	(2.207)
Observations	110,203
R-squared	0.098

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

A.11 State space

The state vector s_t determines which options are in the current feasible action space $D(s_t)$, which utility value is given to the feasible choices and what beliefs and expectations about corresponding future states exist. The vector s_t is observed in every period.

$$\begin{aligned} s_t =& \{H_{t-1}, JO_t, CD_t, expEQ_t, age_t, lrage_t, retyears_t, careyears_t, \\ & mar_t, educ_t, malive_t, falive_t, mage_t, fage_t, fhealth_t, mhealth_t, pdist_t, sibl_t\} \end{aligned} \tag{23}$$

H_{t-1} is past choice on work, JO_t and CD_t inform about job offer and care demand probabilities in the current state. Only if these exist, the agent can chose to provide labor and provide some kind of (in)formal care. Further, the state space includes the agent's age age_t, the legal retirement age $lrage_t$, job experience $expEG_t$, time since retirement $retyears_t$, times spend in care provision $careyears_t$, being married mar_t, being highly educated $educ_t$ and information about the parents: If mother and/or father are alive ($malive_t$, $falive_t$), their age ($fage_t$ and $mage_t$) and health ($fhealth_t$, $mhealth_t$) and whether they live close by ($pdist_t$). Further, we track the existence of a sibling $sibl_t$.

A.12 Further information on the ML estimation

We approximate the value function using interpolation as suggested in Keane and Wolpin (1994). We use numerical gradients but utilize the BHHH approximation of the Hessian (Berndt et al., 1974). The estimation of type probability function, the interpolation of the value function, and the numerical maximization procedure are described in detail in the appendices A.13 A.14 and A.15, respectively.

A.13 Unobserved type probability

The probability of belonging to type m is modeled conditionally on working experience at age 55[52], on number of children, and whether the women is highly educated.[53] The probability is estimated within the ML estimation.

$$\begin{aligned} P(m=1) =& \frac{exp(\alpha M_{T_0})}{1+exp(\alpha M_{T_0})} \\ \alpha M_{T_0} =& \alpha_0 + \alpha_1 age_{T_0} + \alpha_2 expEQ_{T_0} + \alpha_3 children_{T_0} \end{aligned} \tag{24}$$

By making the type probability function conditional on state variables in the initial period, we account for non-random initial conditions at the initial period. This approach follows (Wooldridge, 2005). It

[52]In SHARE data we use the retrospective SHARElife data set to retain this information for those respondents who are not observed at age 55.

[53]We follow (Korfhage, 2019) in estimating the type probabilities. However, we introduce educational attainment into the function. In contrast to (Korfhage, 2019) the type is important only for taste for leisure time and preferences for informal and formal care. We do not estimate differences in wages and non-labor income by type.

Table 23: Parameter results for unobserved type estimation

Description	Parameter	Coefficient	S.E.
Intercept	λ_1	-1.03	0.26
High education	λ_2	1.13	0.14
Experience at age 55	λ_3	0.04	0.01
Number of children at age 55	λ_4	-0.01	0.06
High education	λ_5	1.00	0.17

requires that the initial condition is random conditional on working experience, education and number of children in the previous period.

Table 23 gives the parameters and standard errors estimated inside the maximum likelihood estimation.

A.14 Approximation of the value function

Instead of solving the value function at the entire state space, we approximate the value function using interpolation as suggested in (Keane and Wolpin, 1994). We follow (Korfhage, 2019) in this way. That is, starting at the terminal age T, we calculate the value functions at a subset of the state space. This grid includes two values of labor market experience (0, 30), two values of years in retirement (0, 6), years in intensive care (0, 5), father age (70, 90), and mother age (70, 90). Further, it includes states which are not interpolated. I.e., individuals' type (1, 2), father died last period (0, 1), mother died last period (0, 1), father alive (0, 1), mother alive (0, 1), health of father (1, 2, 3), health of mother (1, 2, 3), existence of siblings (0, 1), parents live close by (0, 1) married (0, 1), education (low, high). In contrast to (Korfhage, 2019) we reduce the number of grid points for experience in order to reduce the size of the overall grid. This results in a total of 229.376 grit points including the 14 ages but excluding the choices. While solving the model recursively, we use a linear interpolation function to predict the value function at values of the state variables that are not included in the grit.

A.15 Numerical maximization of the likelihood function

[54] The log-likelihood function takes the form $LL(\theta) = lnL(\theta)$, where $L(\theta)$ is function 13. For simplicity, all coefficients are collected in vector θ. After specifying a vector of starting values θ_0 the Newton-based algorithm stepwise approaches the maximum. That is, the algorithm is based on a second order Taylor approximation around θ_τ. The next iteration value is found by maximizing the Taylor approximation with respect to the step to the next iteration value (for an overview of different numerical optimization

[54] We follow (Korfhage, 2019).

methods, see for example (Train, 2009), Ch. 8). It is defined as

$$\theta_{\tau+1} = \theta_\tau + \lambda B_\tau^{-1} g_\tau \tag{25}$$

, where $g_\tau = \quad (\frac{\partial LL(\theta)}{\partial \theta})_\tau$ is the gradient vector of first derivatives and B_τ is the approximation of the negative Hessian, the matrix of the second derivatives $H_\tau = \quad (\frac{\partial^2 LL(\theta)}{\partial \theta \partial \theta'})_\tau$. The Newton-based methods hence require gradients and the Hessian matrix. As the gradients are difficult to derive analytically, I use numerical approximations of the scores. For each individual i we calculate the score as

$$s_i(\tau) = \frac{LL_i(\theta_\tau + h) - LL_i(\theta_\tau)}{h} \tag{26}$$

, where $h = 10^-6$ and LL_i is the individual contribution to the likelihood. The scores are used to calculate the gradient vector $g_\tau = \sum_i s_i(\tau)/N$ and the BHHH approximation of the Hessian. It is calculated as the average outer product $B_\tau = \sum_i s_i(\tau) s_i(\tau)'/N$ (Berndt et al., 1974).

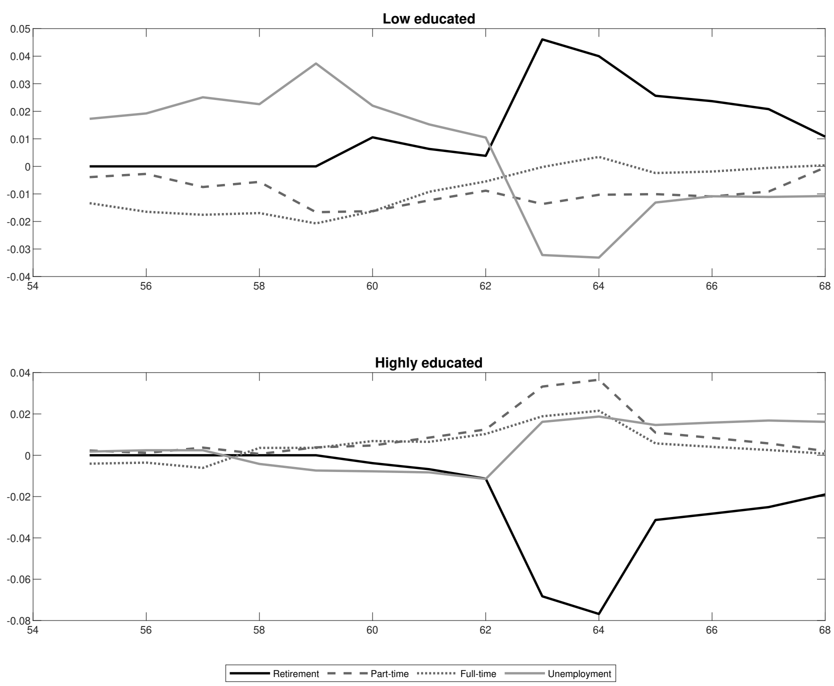
A.15.1 Effects of decreased pension system generosity

In this section, we describe impacts of reduced pension benefit receipt on employment, retirement behavior and the resulting effects for care provision. We compare the baseline simulation performed on our dynamic model with a scenario in which all pension benefits are reduced by 20%. Reforms of the pension system often aim at increasing the financial sustainability of the pension system. In order to achieve this goal, policy makers often increase the pensionable ages. As many individuals still go into retirement early, this has the affect of a reduction of pension benefits. Further, in this section we aim to understand the dynamic incentives the pension system has on care provision.

Figure 11 shows employment and retirement responses by age and education. Changes to individual's retirement behavior start off at age 60 with a small increase. The overall effect on retirement in the population is very small. The mean retirement age in the population is decreased by 0.014 years. As we look into effects by education, we find that lower educated women retire earlier: they show a peak in the effect size at age 63 (4.61pp; 9.36%) which then dies off to 1.1pp at age 68. Higher educated women delay retirement and show the biggest decrease in their retirement probability at age 64 (-7.7pp, -12%). Employment responses also differ by education: Lower educated women show an increase in unemployment until age 62 with a peak at age 59 (3.73pp; 9.25%) and a decrease in unemployment after age 62. At age 64, lower educated women show a 3.3pp (12.06%) lower probability to be unemployed. Higher educated women show smaller impacts on unemployment. Before age 62, highly educated women show small reductions in unemployment, from age 63 onward, the reform affects unemployment for this group positively: At age 64, highly educated women show a 1.87pp (13.57%) higher probability to be unemployed. Lower educated women react by decreasing employment in all ages, with highest reactions at age 59 in part-time employment (1.66pp, 4.57%) and full-time employment (2.07pp, 6.45%). Higher educated women first reduce full-time employment slightly (0.6pp or 1.3% at age 57) and then increase full- and part-time employment. At age 64 part-time employment increases by 3.66pp (25.26%) a full-time employment by 2.15pp (27.8%).

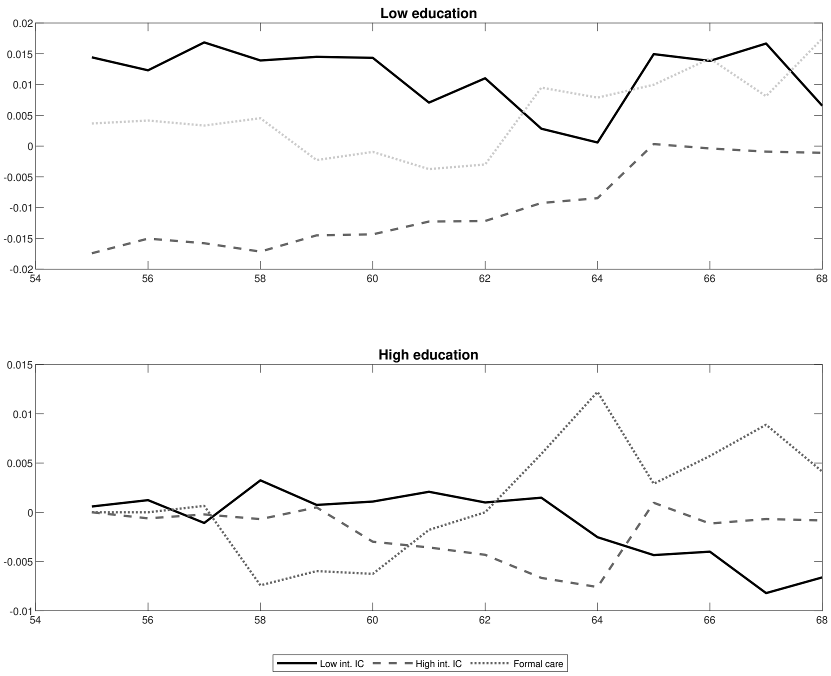
The pattern emerges as before the pensionable ages, employment becomes less profitable because as pension benefits are reduced, so is the increase in pension benefits through more time in employment. Lower educated women appear to react to this reduced incentive by decreasing employment before and after age 60 and hastening retirement. Highly educated women, on the other side react by slightly decreasing employment before age 60. After age 60, highly educated women react to decreased opportunity costs of working and prolong their working lifes. Overall we find a 1.45% decrease in hours worked.

Figure 11: Employment responses to reduced pension generosity



Reaction in care provision due to the reduction of generosity in the pension system can go in different directions: On the one hand, the fact that one can collect pension points in informal care provision connects the LTC supply to the dynamic incentive structure of the pension system. One would expect a reduction in informal care supply. On the other hand we could show employment reactions in all ages which would have counteracting effects on informal care supply due to changes in the time conflict for some individuals. Further, lower pension benefits relatively increase the attractiveness of LTC benefits and with that reduce the opportunity costs of informal care supply.

Figure 12: Care responses to reduced pension generosity



In figure 12 we show informal and formal care reactions to reduced pension generosity by age and education. We see in the upper panel (lower educated women) that especially in early ages (until age 62) the supply of high intensity informal care is reduced by 25.3%. Low intensity IC is increased by 7.79% and overall we find a 0.24% increase in informal care supply for lower educated women before age 62. In later ages (from age 62 onward), high intensity care picks up again but we still find a 11.2% decrease. Low intensity care is decreased by 0.57%. Overall the probability that informal care is provided is reduced by 0.2%. Formal care demand is reduced slightly by 0.21% before age 62 and increased by 1.88% after age 62 for lower educated women.

Higher educated women show a similar pattern but lower reactions: Before age 62, low intensity care is increased by 0.8% and high intensity care is reduced by 1.5%, adding up to a 0.02% decrease in informal care supply. From age 62 onward, high intensive care is reduced by 5.92% and low intensive care is decreased by 1.04%; overall, this adds up to a small increase in informal care supply by 0.83% for ages from 62 onward for highly educated women. Formal care demand is decreased for highly educated women (0.77% reduction before age 62 and 0.93% increase after age 62). Overall, informal care hours are reduced by 4.63%. The pattern shows several aspects: First, the incentive to collect pension points in informal care supply is very important, especially for high intensive informal care. As this incentive is smaller now, high intensive IC is reduced substantially. In pension ages (age 62 and onward), low intensity informal care increases go down as more labor is supplied. At the same time, as pension benefits are lower, LTC benefits especially in high intensive IC become more attractive and decreases in high intensive IC are lower. Formal care is increased especially in upper ages as more women are active on the labor market and receive labor earnings. These labor earnings are higher than pension benefits and thus, formal care usage becomes relatively cheaper.

In a next step, we show effects of reduced pension system generosity on life-time earnings. In this simulation, again, we do not compensate for forgone pension payments. Therefore, we expect life-time earnings to decline. Pension payments decline for all women. Labor income, however can be impacted positively or negatively due to differential changes in labor supply. Table 27 in the Appendix shows effects. While total labor earnings increase, the first and fourth income quartile increase labor earnings and the second and third income quartiles decrease labor earnings. While women in the lowest quartile increase the total number of working hours by 0.81%, women in the second income quartile decrease the total number of working hours by 6.53%. In the third income quartile we find a decrease in the total number of working hours by 2.3% and in the top income quartile, we find an increase by 2.13%. Women in the lowest income quartile often have no partner. For them, reduced pension generosity leads to higher relative income losses and consequently they experience a higher incentive to work more. Losses in NPV of retirement benefits are highest for the lowest income quartile. If we look at losses in relative terms, the lowest income quartile suffers most from reduced pension generosity. This is mostly due to the fast, that women in this group often have no partner and income effects are higher in relative terms. Also, impacts on total earnings are highest in the lowest income quartile. Women in upper quartiles also suffer reductions in the NPV of total earnings, however, these losses are smaller in relative terms. We find that overall women with at least one parent that is alive at age 55 (women with care-demand) increase labor income more in absolute terms than women without care-demand. We find that women in the lowest income quartile show higher increases in labor income and women in the two middle income quartiles show lower reductions in income as a result of the reduction in pension generosity. In the highest income quartile women without care-demand increase income more than women with care-demand. Impacts on retirement benefits are comparable between women with and without care-demand in relative terms. However, as women with care-demand often retire earlier than women without care-demand, impacts are higher for women with care-demand in absolute terms. Consequently, reduction in total earnings are higher for women with care-demand. Overall we find that effects on income and total earnings do not differ by care-demand as much in this scenario.

Figure 25 in the Appendix shows well-being effects of reduced pension generosity by income quartile and care-demand. The lowest income quartile shows higher well-being effects than if the retirement ages are increased. The second income quartile experiences lower impacts on well-being than in scenario 1;

women in the third income quartile is impacted more than in scenario 1 and the fourth income quartile is impacted more than in the first scenario.

The second income quartile experiences lowest well-being reductions, while the third income quartile experiences higher negative impacts to well-being. The figure also shows that women with care-demand experience slightly higher reductions in well-being if retirement benefits are lower than women without care-demand. While we could show that they experience slightly higher or comparable impacts on income, well-being is impacted more. This might be due to the fact, that utility is gained with diminishing rate of return with respect to leisure and income.

A.16 Further Tables

Table 24: Retirement ages for German women

Pension pathway	ERA	NRA
Old age pension	-	65 if born pre 1947; increases gradually to 67 for those born in 1964; Criteria: 5 years of waiting period
Old age pension for long term insured	63; Criteria: 35 years of waiting times	65 if born before 1949; gradual increase to 67 if born from 1964; Criteria: 35 years of waiting times
Old age pension for especially long term insured	-	63 Criteria: 45 years of waiting times and born until 1953; gradual increase to age 65 if born from 1964
Women's pension	60; Criteria: born until 1951; 15 years of waiting period, 10 of which have to lay after the age 40	63; Criteria: born until 1951; 15 years of waiting period, 10 of which have to lay after the age 40

Table 25: Care and Working decision

	Caring decision						
	No formal care			Formal care			
Working choice	NIC	LIF	HIC	NIC	LIF	HIC	Total
Unemployed	1,000	39	24	129	30	16	1,238
	80.78	3.15	1.94	10.42	2.42	1.29	100.00
Part-time	856	46	15	105	42	23	1,087
	78.75	4.23	1.38	9.66	3.86	2.12	100.00
Full-Time	692	45	20	124	26	13	920
	75.22	4.89	2.17	13.48	2.83	1.41	100.00
Retired	1,918	40	21	183	29	32	2,223
	86.28	1.80	0.94	8.23	1.30	1.44	100.00
Total	4,466	170	80	541	127	84	5,468
	81.68	3.11	1.46	9.89	2.32	1.54	100.00

Table 26: Transitions

	Data	Simulated
% Nonemployed who are nonemployed again next period	95.34	87.29
% Transition from employmend to nonemployment	31.35	47.42
% Transition from nonemployment to employment	4.66	12.71
% Employed who are employed again next period	68.65	52.58
% Informal noncaregiver who are Informal noncaregiver again next period	94.50	93.11
% Transition from informal caregiving to informal noncargiving	71.99	71.63
% Transition from informal noncaregiving to informal cargiving	5.50	6.89
% Informal Caregiver who are informal caregiver again next period	28.01	28.37
% Formal noncaregiver who are formal noncaregiver again next period	92.41	92.13
% Transition from formal caregiving to formal noncargiving	42.06	60.64
% Transition from formal noncaregiving to formal cargiving	7.59	7.87
% Formal caregiver who are formal caregiver again next period	57.94	39.36

The data average was calculated using the estimation sample. The model predictions were calculated using a simulated sample. The simulated sample was constructed using the dynamic model for work, retirement and care-giving and state variables for each individual in the sample. To ensure comparability with the estimation sample, model predictions were only calculated for with simulation outcomes from ages at which a person was also observed in the data. SHARE, own calculations

A.17 Further figures

Table 27: Response in lifetime earnings (reduced pension system generosity)

	(1) Euro (All)	(2) % (all)	(3) Euro (CD)	(4) % (CD)	(5) Euro (NCD)	(6) % (NCD)
			Δ NPV of labor earnings			
total	6.22e+03	0.77	1.01e+04	0.77	3.01e+02	0.75
1st quartile	3.49e+04	2.42	4.44e+04	2.44	1.99e+04	2.39
2nd quartile	-2.11e+04	-5.79	-1.86e+04	-5.98	-2.46e+04	-5.56
3rd quartile	-5.12e+03	-0.77	-3.62e+03	-0.80	-6.99e+03	-0.74
4th quartile	1.62e+04	2.07	1.52e+04	2.12	1.81e+04	1.98
			Δ NPV of Retirement benefit			
total	-2.28e+05	-1.25	-2.34e+05	-1.23	-2.19e+05	-1.27
1st quartile	-3.39e+05	-8.20	-3.40e+05	-7.73	-3.38e+05	-9.07
2nd quartile	-7.32e+04	-0.38	-7.65e+04	-0.38	-6.87e+04	-0.38
3rd quartile	-2.39e+05	-1.10	-2.45e+05	-1.09	-2.32e+05	-1.11
4th quartile	-2.61e+05	-0.94	-2.65e+05	-0.94	-2.52e+05	-0.94
			Δ NPV of total earnings			
total	-2.08e+05	-1.08	-2.11e+05	-1.07	-2.03e+05	-1.09
1st quartile	-2.98e+05	-5.18	-2.99e+05	-5.05	-2.96e+05	-5.40
2nd quartile	-1.34e+05	-0.67	-1.35e+05	-0.67	-1.32e+05	-0.66
3rd quartile	-2.00e+05	-0.88	-2.03e+05	-0.88	-1.96e+05	-0.88
4th quartile	-2.01e+05	-0.70	-2.05e+05	-0.70	-1.94e+05	-0.70

Notes: NPV: net present values; CD: Care-demand; NCD: No Care-demand

Source, SHARE, own calculations

Table 28: Response in lifetime earnings to increased retirement ages combined with increased collectable pension points

	(1)	(2)
	Euro	%
	Δ NPV of labor earnings	
total	8.71e+04	11.20
1st quartile	8.29e+04	5.34
2nd quartile	7.76e+04	23.74
3rd quartile	8.64e+04	14.33
4th quartile	1.00e+05	14.22
	Δ NPV of Retirement benefit	
total	-6.24e+05	-3.25
1st quartile	-2.26e+05	-4.56
2nd quartile	-7.96e+05	-4.04
3rd quartile	-6.69e+05	-2.90
4th quartile	-8.02e+05	-2.84
	Δ NPV of total earnings	
total	-1.11e+05	-0.51
1st quartile	-6.50e+04	-1.01
2nd quartile	-1.51e+05	-0.73
3rd quartile	-9.44e+04	-0.33
4th quartile	-1.30e+05	-0.41

Notes: NPV: net present values

Source, SHARE, own calculations

Table 29: Response in lifetime earnings (introduction of care-times combined with increased retirement age)

	(1) Euro (CD)	(2) % (CD)
	Δ NPV of labor earnings	
total	1.49e+03	4.90
1st quartile	2.79e+03	2.04
2nd quartile	2.60e+04	15.39
3rd quartile	-1.52e+03	6.85
4th quartile	-1.88e+04	3.94
	Δ NPV of Retirement benefit	
total	-6.48e+05	-3.33
1st quartile	-2.47e+05	-4.85
2nd quartile	-8.14e+05	-4.09
3rd quartile	-6.96e+05	-2.97
4th quartile	-8.28e+05	-2.90
	Δ NPV of total earnings	
total	-1.69e+05	-0.69
1st quartile	-1.16e+05	-1.52
2nd quartile	-1.90e+05	-0.84
3rd quartile	-1.60e+05	-0.49
4th quartile	-2.07e+05	-0.59

Notes: NPV: net present values; CD: Care-demand

Source, SHARE, own calculations

Figure 13: Care mix by health; unconditional left, conditional on outside care received right (SHARE data)

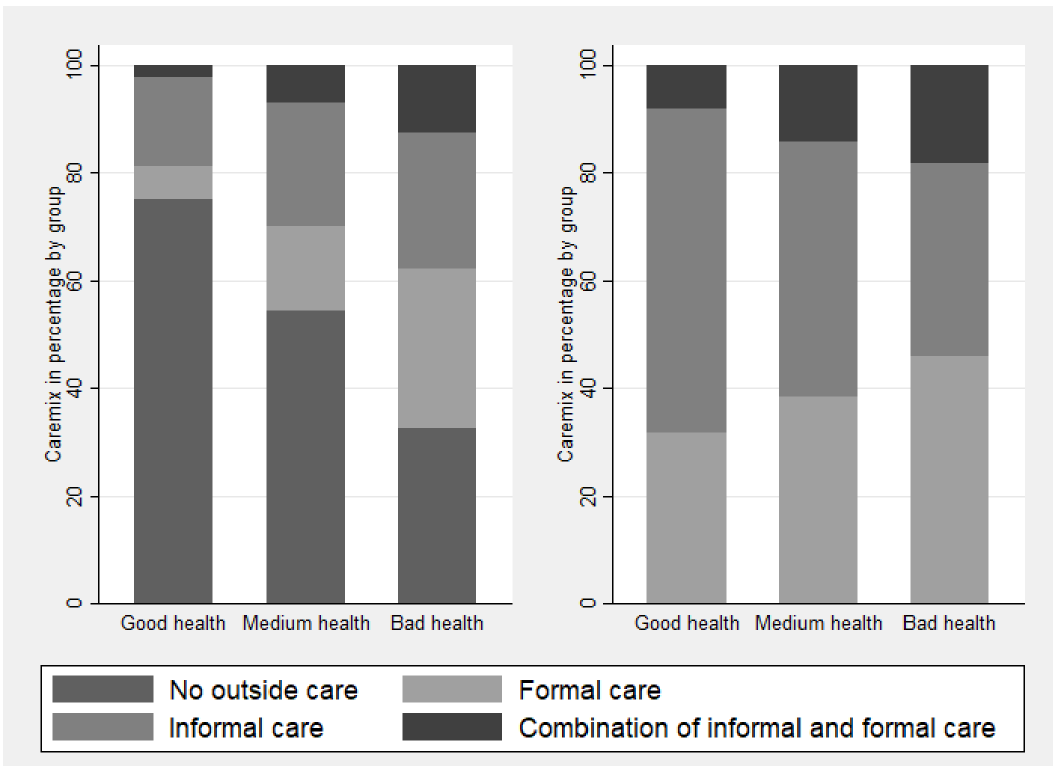


Figure 14: Care mix by children, child distance and marriage status (SHARE data)

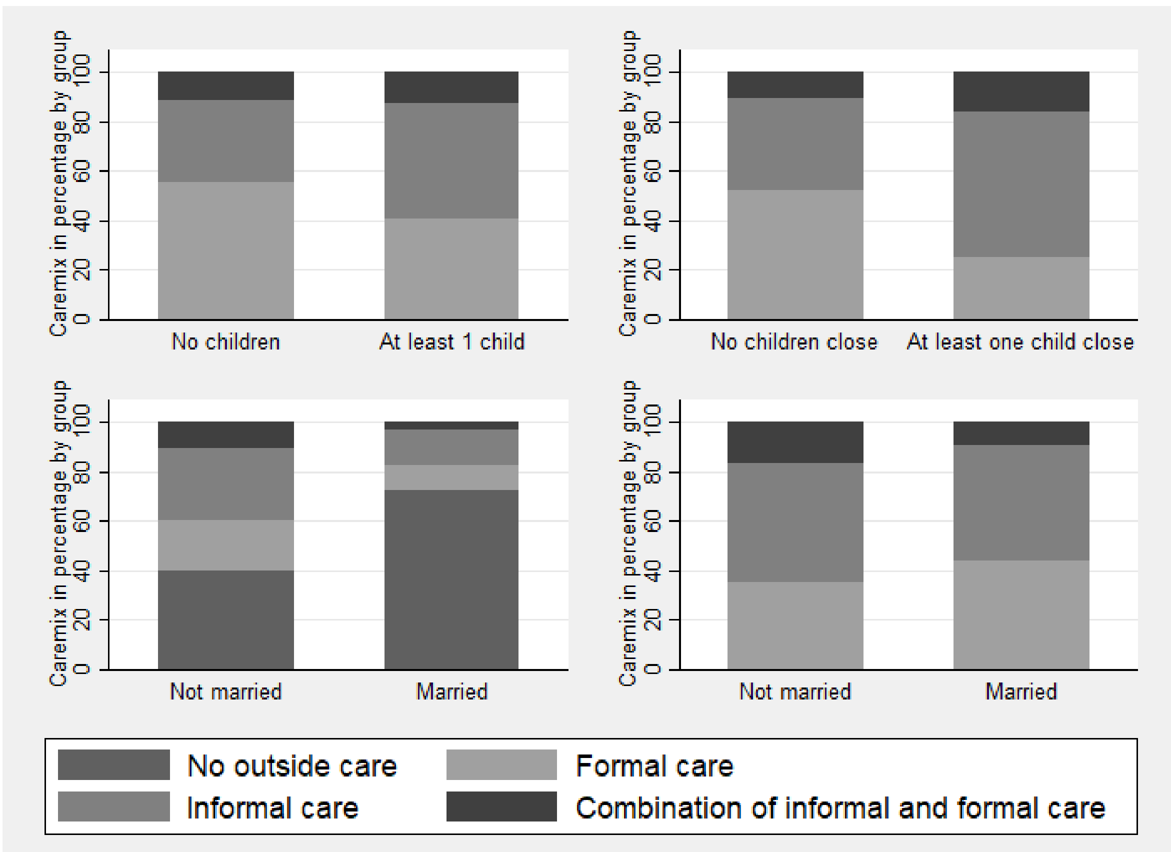


Figure 15: Care mix in estimation data by age of agent

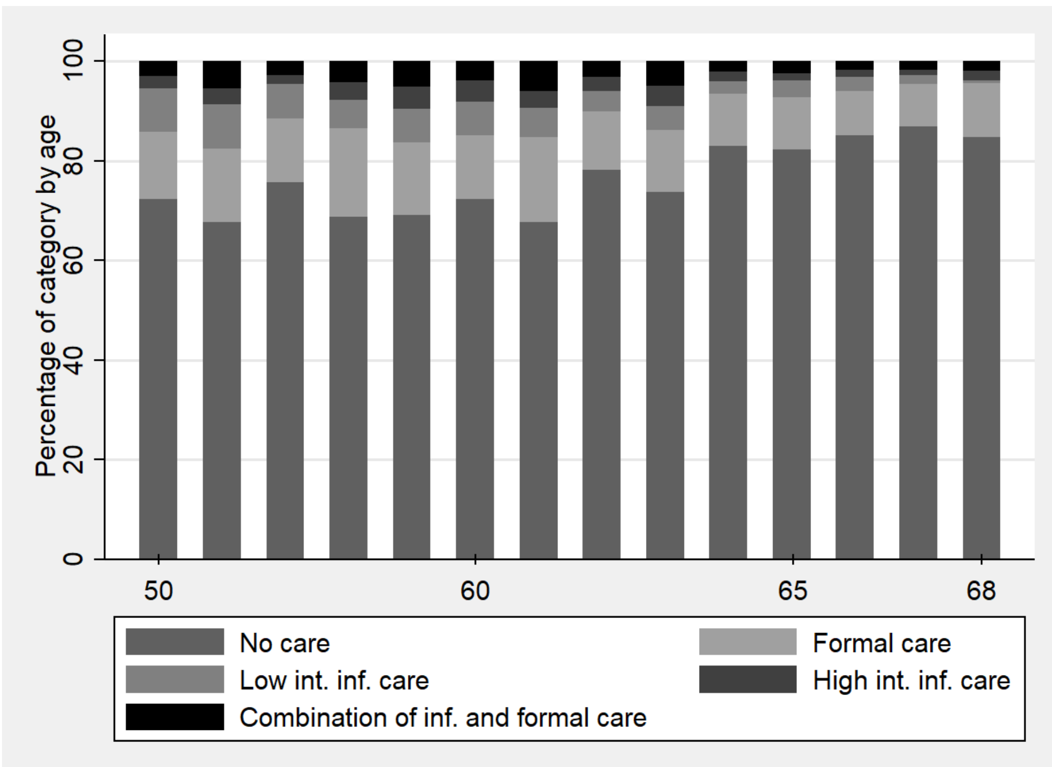


Figure 16: Retirement behavior of women in SOEP data by age

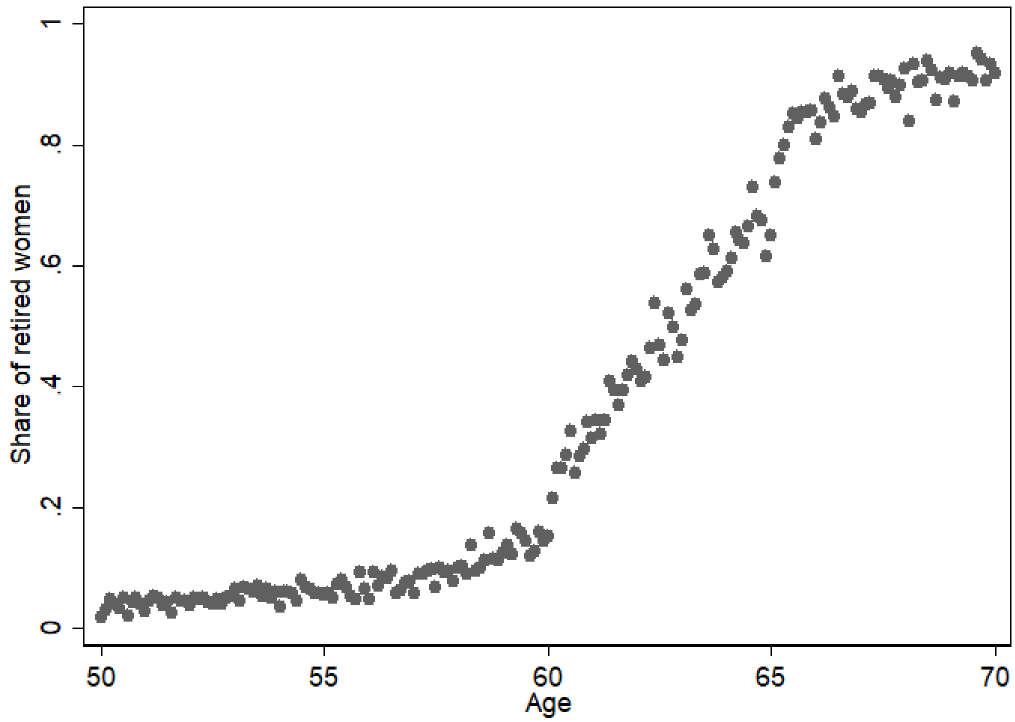


Figure 17: Care mix by age, among all (left) and those with at least one parent (right)

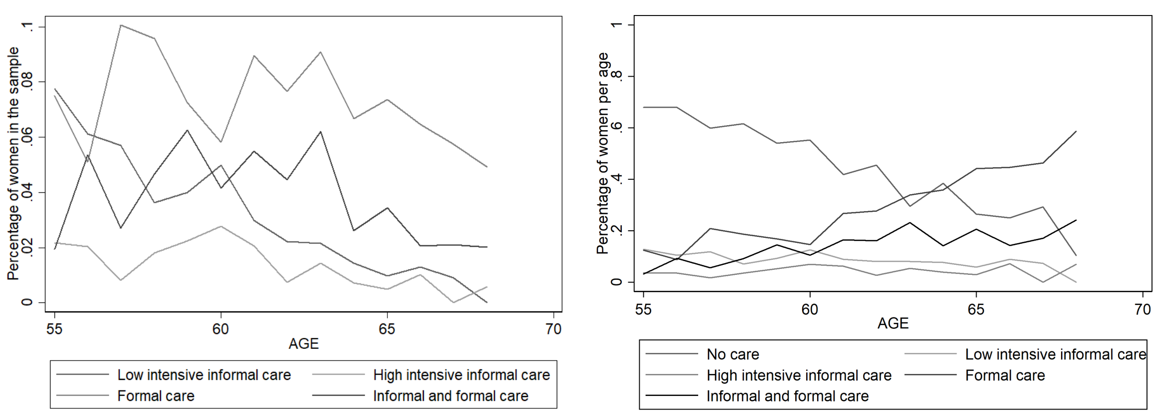


Figure 18: Model fit: formal and informal care decisions by age

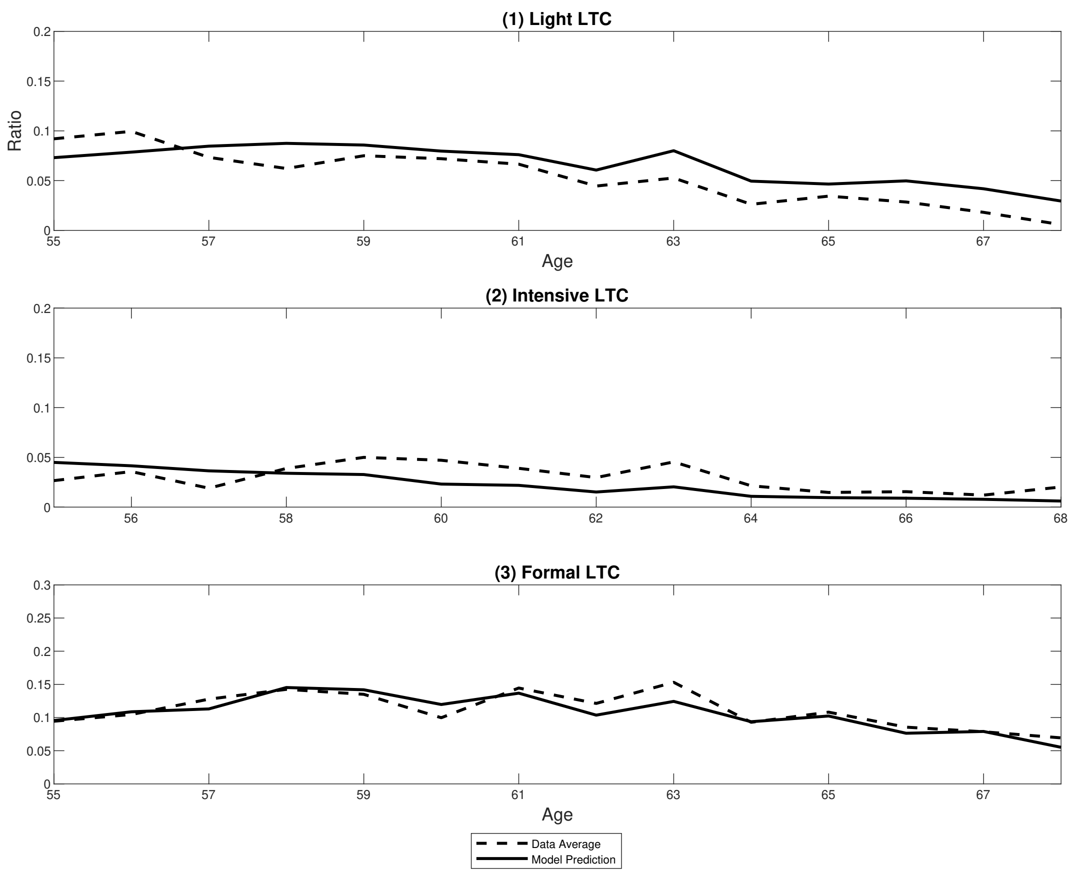


Figure 19: Model fit: formal and informal care decisions by age and education

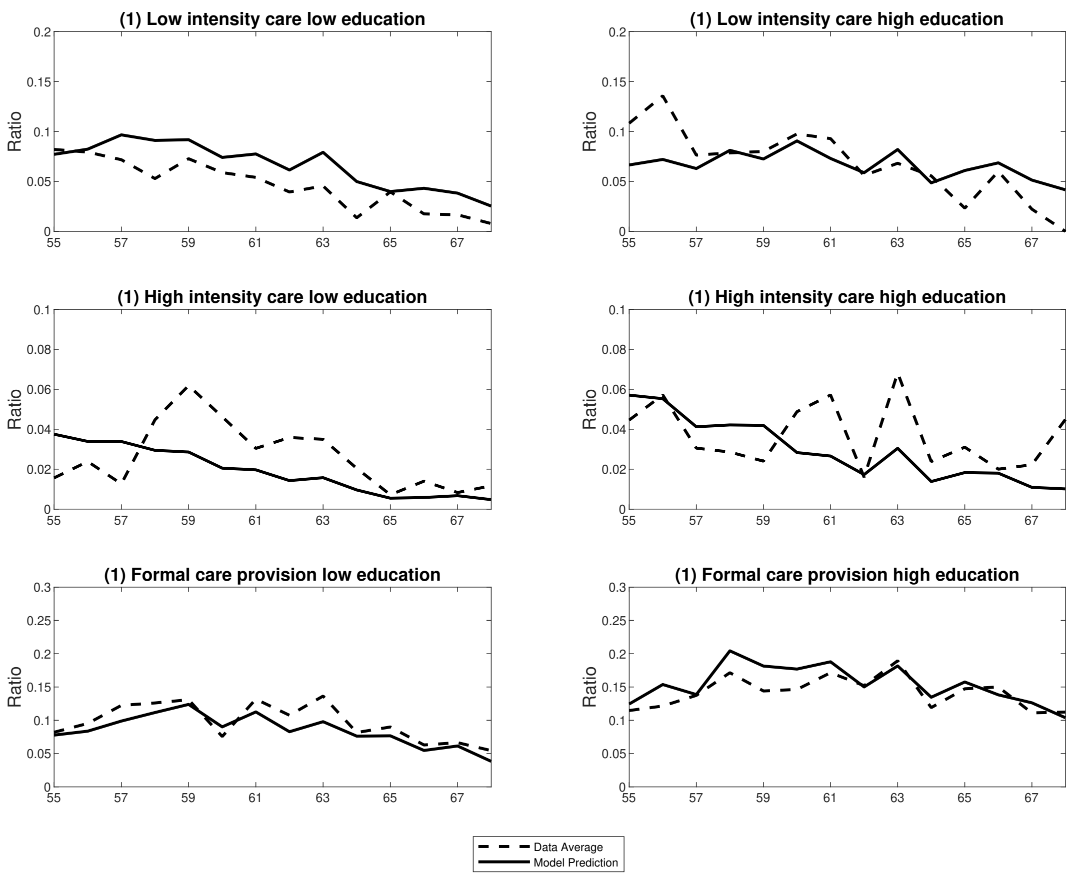


Figure 20: Model fit: formal and informal care decisions by age and existence of siblings

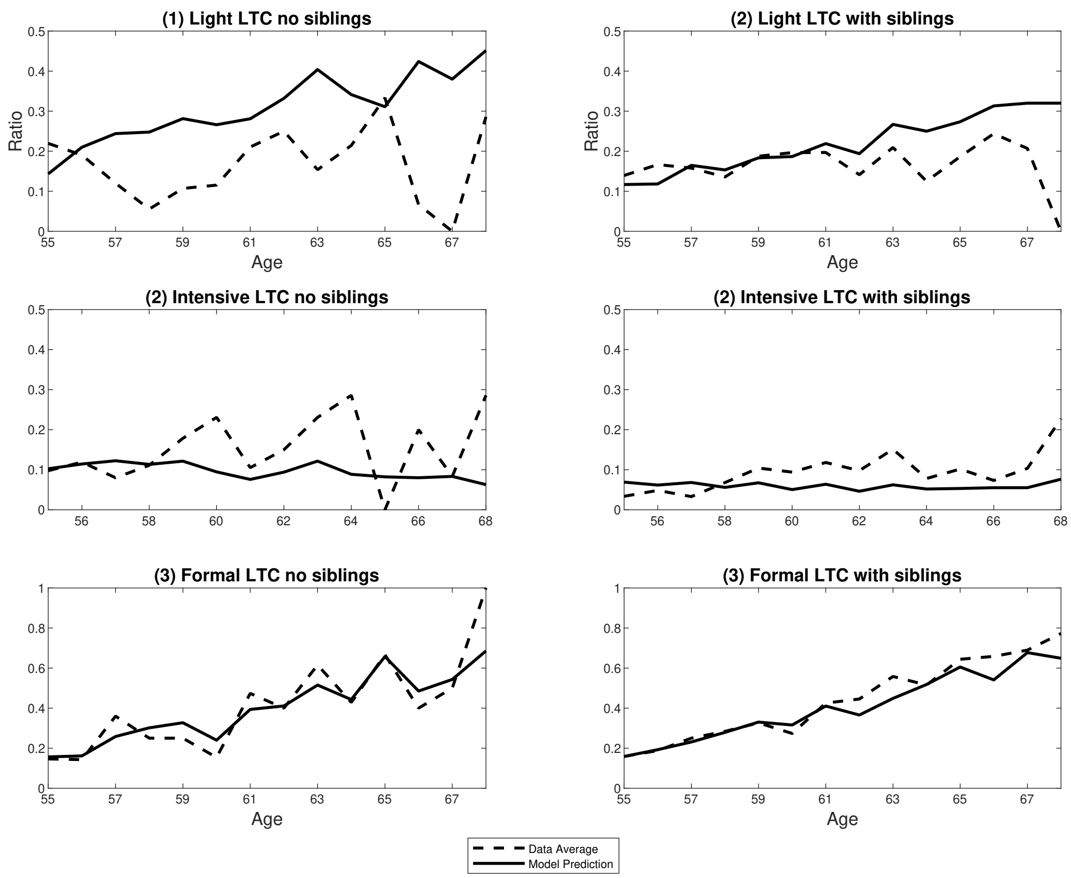


Figure 21: Model fit: formal and informal care decisions by age and distance to parents

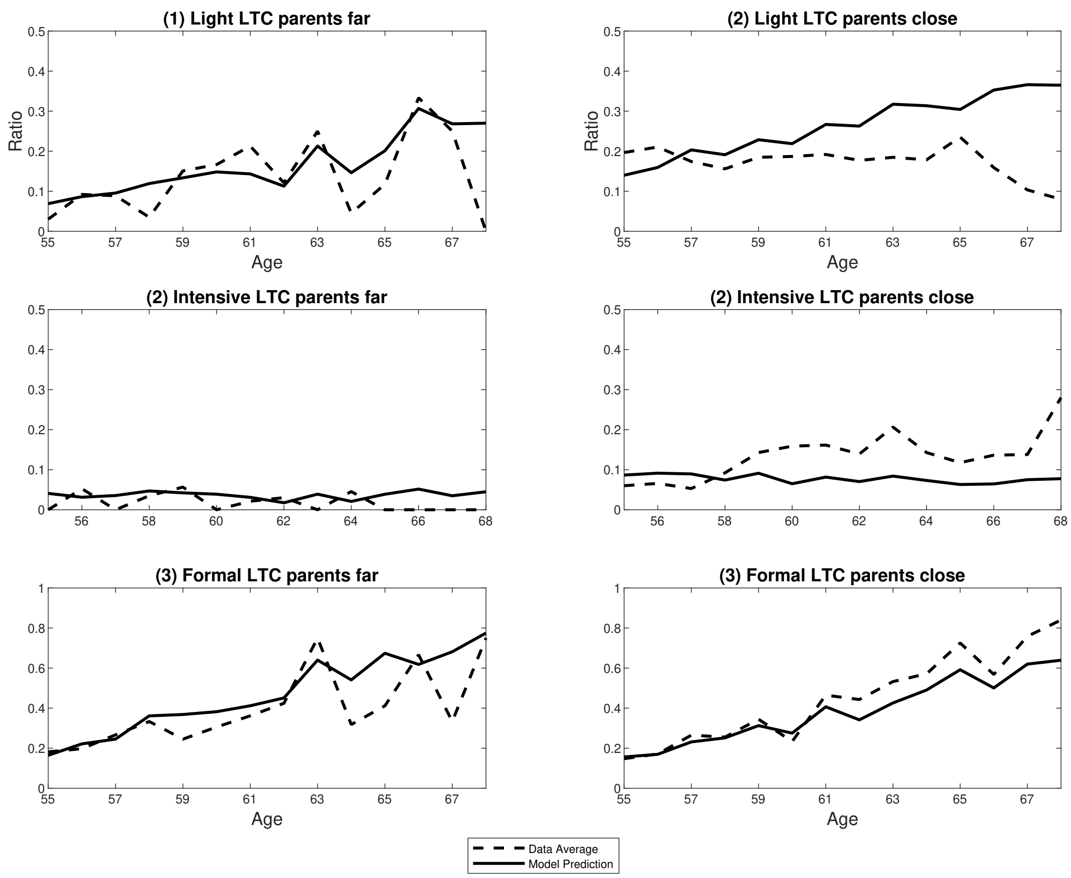


Figure 22: Model fit: formal and informal care decisions

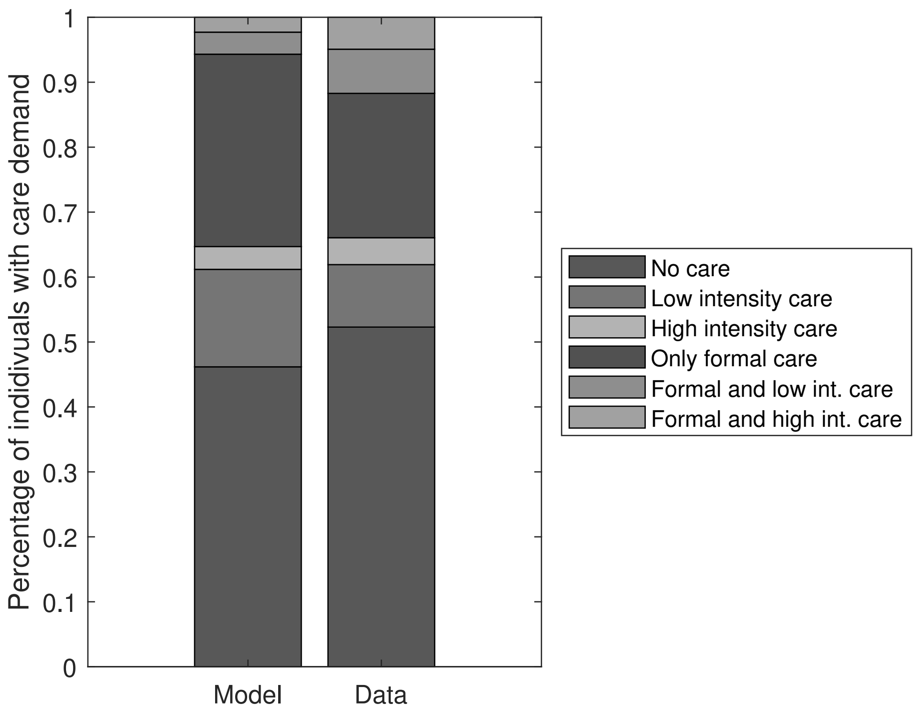


Figure 23: Effects of a 10% increase in female labor force participation at age 54 on caring behavior

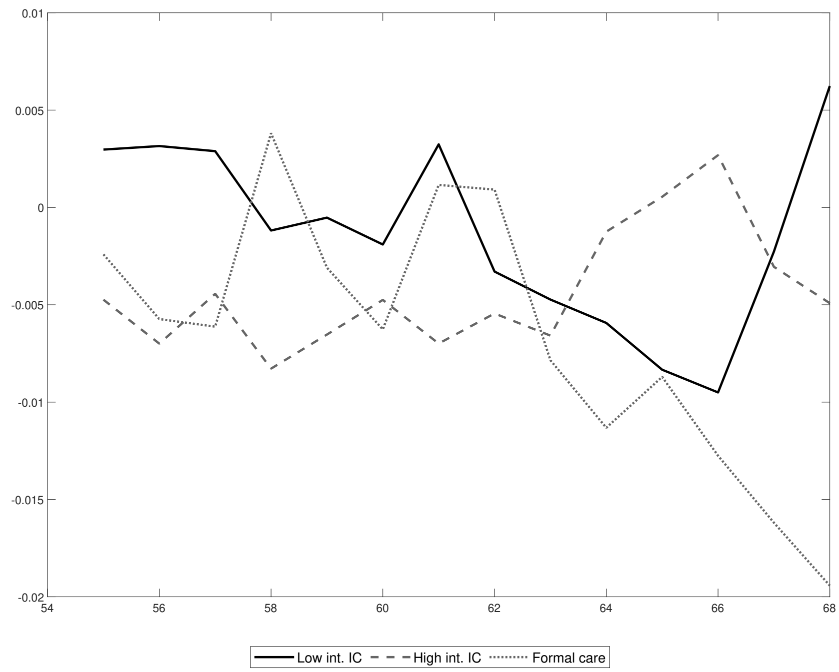


Figure 24: Employment effects of abolishing women's pension

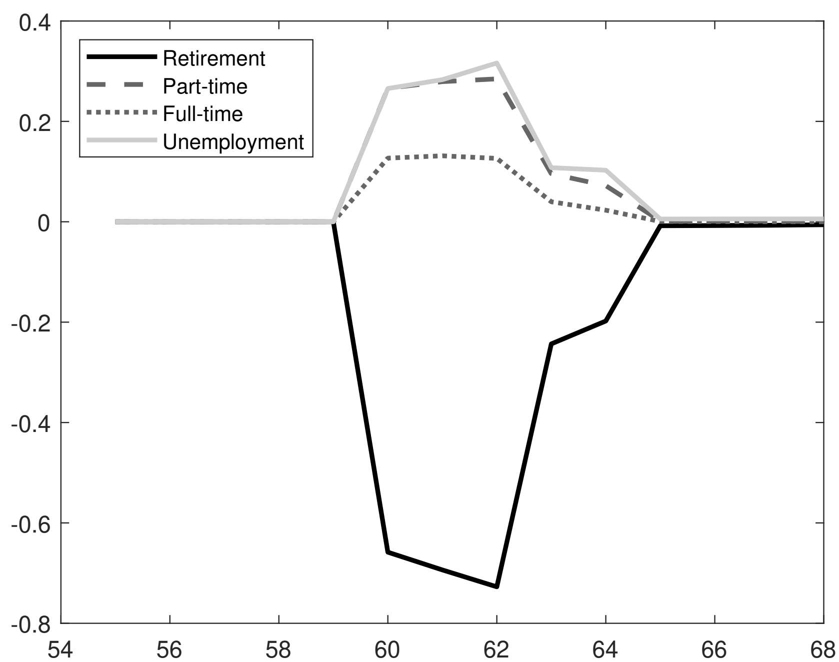


Figure 25: Welfare responses to decreased pension generosity

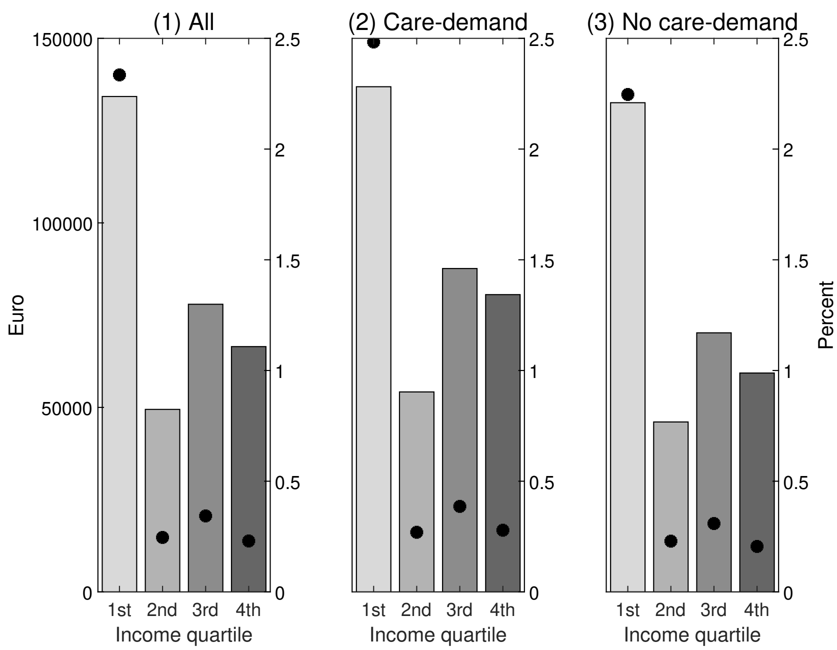


Figure 26: Care responses to increased retirement ages combined with increased collectable pension points

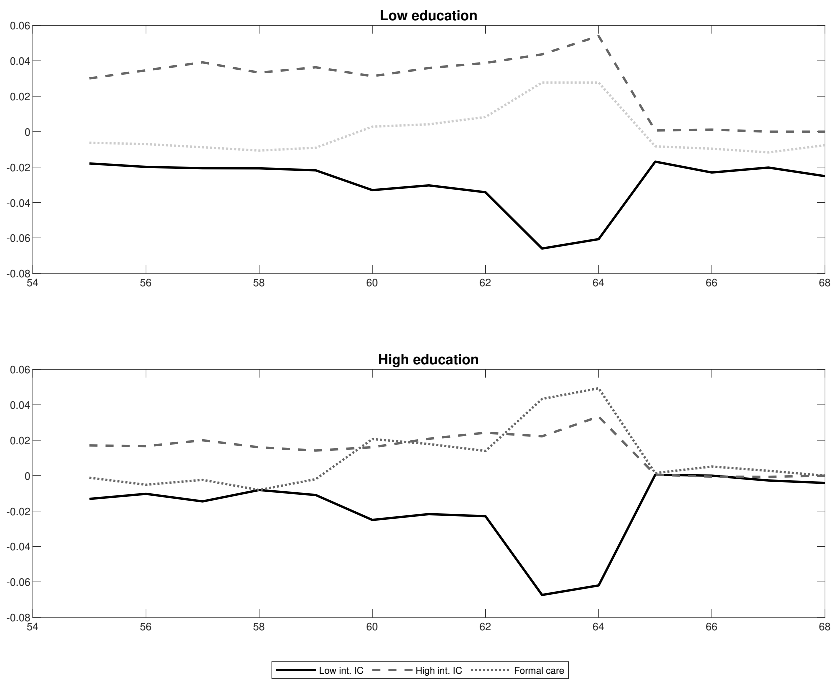


Figure 27: Employment responses to increased retirement ages combined with increased collectable pension points

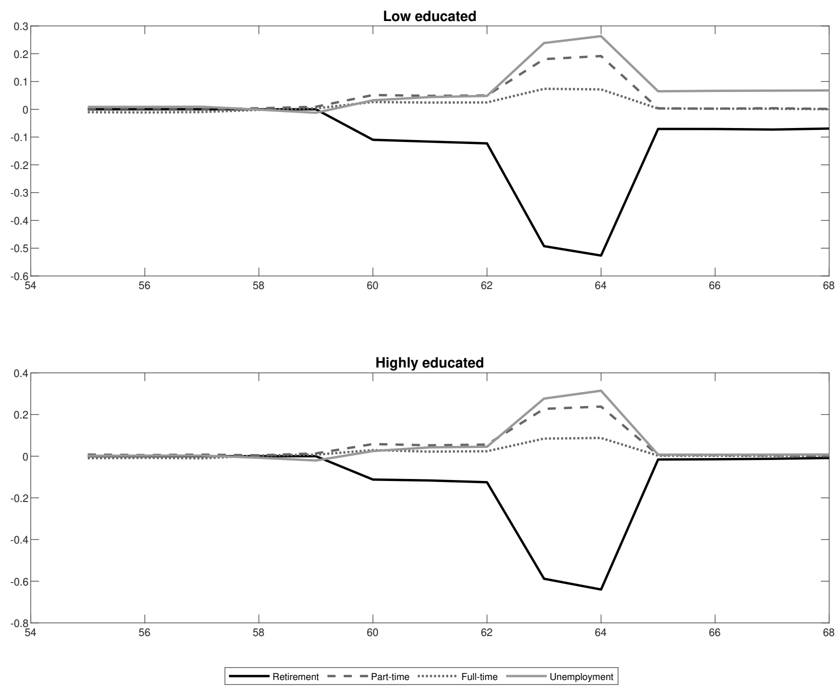


Figure 28: Employment responses to the introduction of care-times

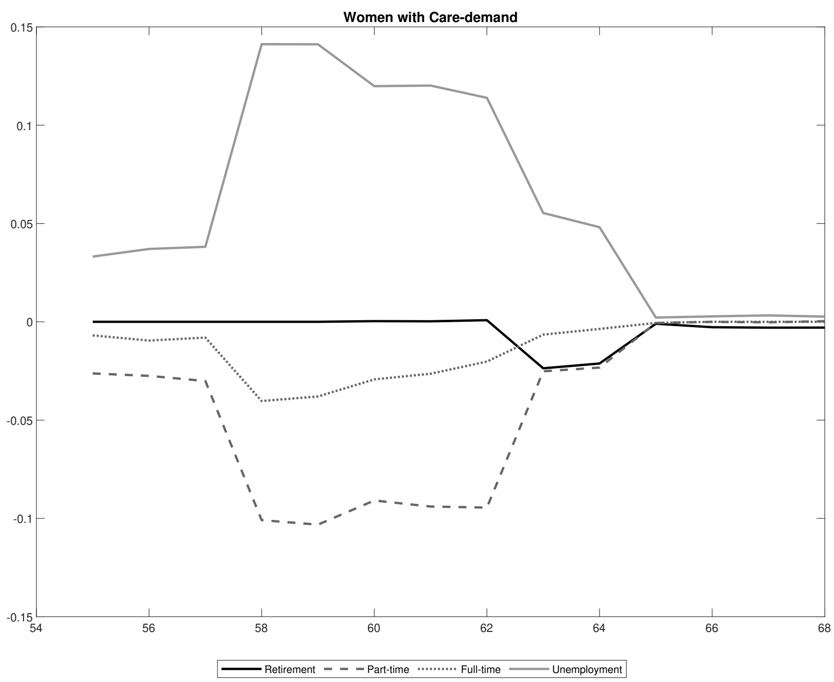


Figure 29: Caring responses to increased retirement ages combined with the introduction of care-times

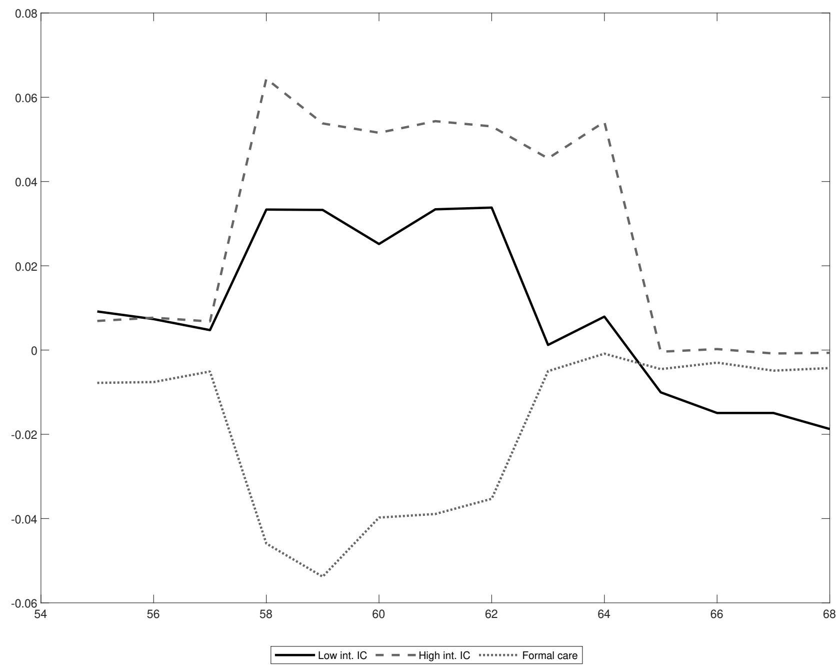


Figure 30: Employment responses to increased retirement ages combined with the introduction of care-times